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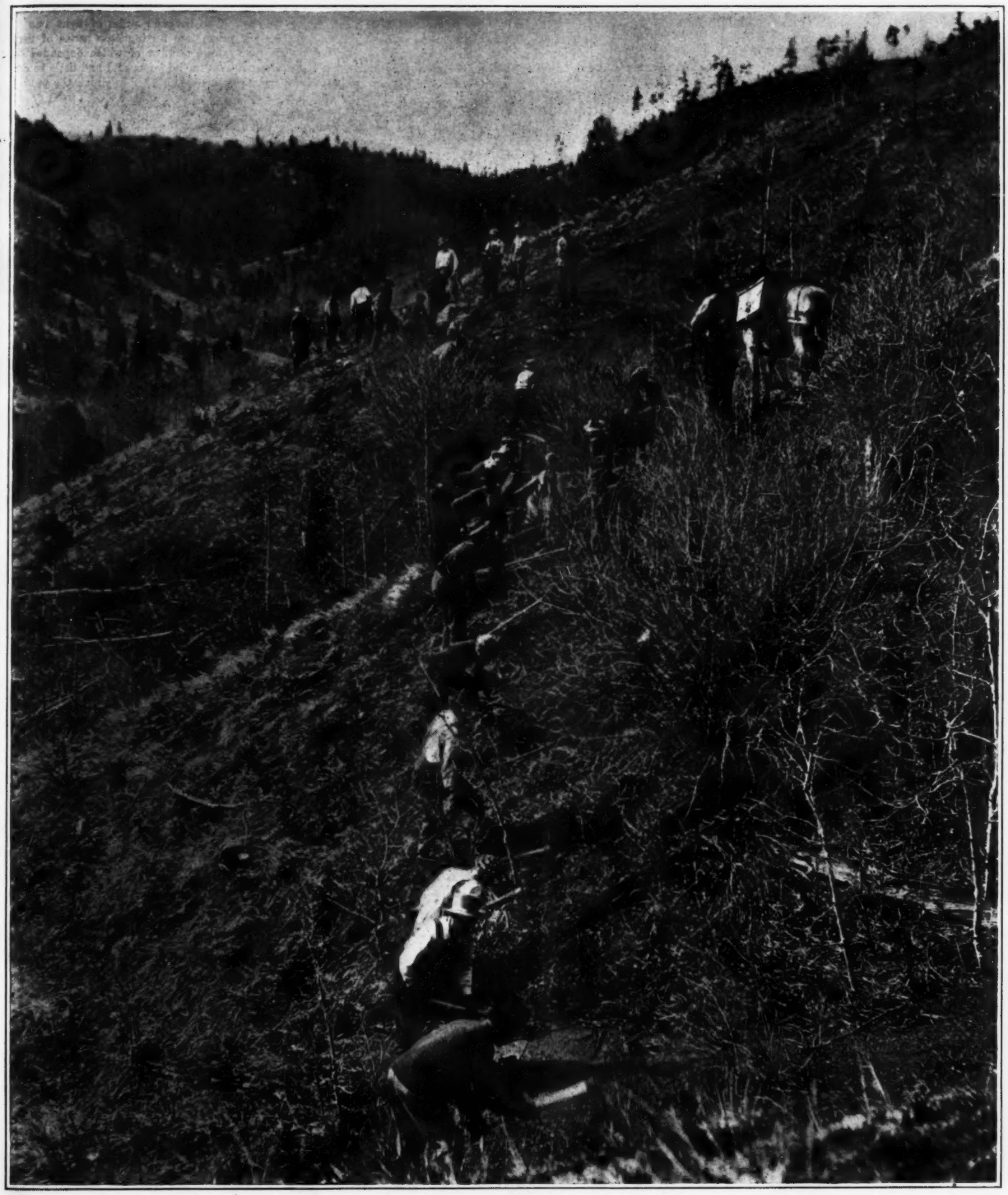


Forestry students learning to plant young trees on a bare hillside.

TEACHING SCIENTIFIC FORESTRY.—[See page 296.]

Radiation From Atoms and Electrons—I*

A Study of the Character of the Mechanism Within the Atom

By Sir J. J. Thomson

For some years past, Sir J. J. Thomson, P.R.S., O.M., has given a course of lectures at the Royal Institution in which modern views on physical science are set forth in plain language and with singular lucidity. The subject chosen for this year's course is that of the "Radiations from Atoms and Electrons."

In opening his address he said that the main object of studying the radiations from atoms and electrons was to form some idea as to the character of the mechanism at work within the atom by which the observed radiations were produced. In this first lecture he proposed to consider certain difficulties met with in interpreting, by this study of the radiations, the nature of the vibrator in which they had their source. He would illustrate these difficulties by the case of light. Discussions as to the real nature of white light had been very prominent during the past twenty years. Until Lord Rayleigh called attention to the subject it had, in fact, been thought that the existence of interference bands necessarily implied a very great regularity in the vibrations of the luminous body producing the light. He would, however, he thought, be able to make clear that these interference effects did not provide an unambiguous method of getting at the nature of the vibrators concerned. It was now held, in short, that the regularity of ordinary interference bands had nothing whatever to do with the vibrator, but depended entirely on certain peculiarities of the instruments used, or of the medium passed through by the light in the interval elapsing between its emission and its reception on the screen. He would, he proceeded, illustrate this by experiment. Having a long piece of stout rubber tubing stretched between the lecture-table and the ceiling of the auditorium, Prof. Thomson showed that on striking the lower end of this tube a sharp blow, the resulting disturbance traveled up the tube to its point of suspension, and was then reflected back again, the "hump" produced by the blow running up and down the tube two or three times. He called attention to the fact that during the whole of this time the "hump" retained its shape unaltered. There was no tendency for it to spread over a greater length of the tube, but during the whole period of its existence the disturbance at any moment was confined to a short length only. The phenomenon, in fact, corresponded closely to that produced by a sharp tap or by the crack of a whip, the noise of which was propagated through the air, and at each point reached, the sound lasted only as long as the time originally taken to produce it. The sound, in fact, remained sharp, without any tendency to prolongation. Under certain conditions, however, it was possible, he said, to prolong the sound of such a crack and to make it equivalent to a musical note lasting a much longer time than the original disturbance, although the latter had itself none of the characteristics of a musical note.

Possibly some of his hearers had observed that if they stood at a little distance in front of a long flight of steps, the sound made by clapping the hands was reflected back by the steps as a prolonged echo, equivalent to a musical note of definite pitch. This effect arose because the foot of the disturbance on meeting the nearest step was reflected back, but the rest of the impulse passed on until it met the riser of the second step, from which another portion was reflected, and so on for the rest of the steps. The case was, in short, equivalent to that of thunder and lightning. The sharp crack due to the flash lasted only an infinitesimal time, while the thunder was due to a succession of reflections of this sharp crack from different clouds. In the case of the steps, as the distance passed over by the disturbance between each successive reflection was the same, there was a definite and identical interval between the successive reflections reaching the ear, and the sound received had accordingly the character of a musical note, although it originated in a disturbance possessing nothing of this character. The extent to which this note was prolonged depended, moreover, solely on the number of the steps, and not at all on the time during which the original disturbance lasted. In fact, from the report of a pistol a sound could be obtained lasting as long as there were additional steps to act as reflectors.

It would thus be seen that the study of a noise as received by the ear need not necessarily be a guide to the character of the disturbance which originally excited it, but might give merely the number of steps in the reflecting object.

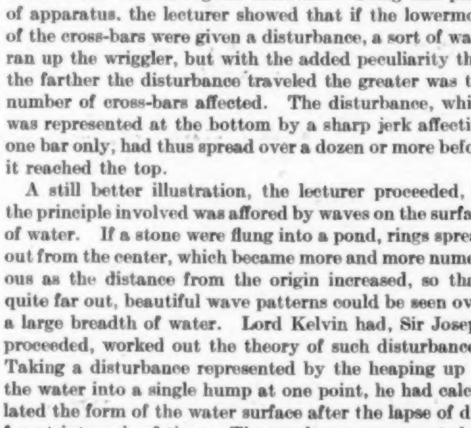
As a further illustration of the principle here involved, the speaker took another tube of rubber similar to that already mentioned, but to which at equally-spaced points of its length a series of weights had been secured. On repeating his original experiment the sharp hump produced initially was partially reflected as it passed each of these weights, with the result that a disturbance having a periodic character was reflected down the tube.

The application of these analogies to light would, he said, be apparent if a grating were considered as consisting of a number of equally spaced reflecting bands separated from each other by transparent intervals. Light reaching the grating from any source would be reflected in a regular succession of separate disturbances, and the final result would depend entirely on the grating, and not at all on the character of the original disturbance. If the reflecting bands were sufficiently numerous, interference effects could be obtained, but these would be merely a measure of the fineness of the grating and could tell nothing as to the periodic nature or otherwise of the original disturbance. Hence, even when the velocity of propagation was the same for all disturbances, we could produce a regular succession of waves, even when the original disturbance was a sharp pulse. An explanation could thus be obtained of the action of a grating in giving a regular spectrum even if the original source were as disconnected and as abrupt as possible. It was accordingly impossible to tell from the reflections produced by a grating anything as to the nature of the source, since the grating would produce light of definite wave-lengths, even when there was nothing of the kind in the original light.

The discussion of the corresponding effect produced by prisms was more difficult. Suppose, for example, an irregular disturbance to enter a refractory medium. Such media did not transmit all disturbances at the same speed; and the consequences were important.

To illustrate this the speaker took as a model of such a medium a Kelvin "wriggler" suspended from the ceiling of the lecture room. This "wriggler" consists of a long vertical wire crossed by heavy horizontal bars of wood fixed to the wire at regular intervals. Using this piece of apparatus, the lecturer showed that if the lowermost of the cross-bars were given a disturbance, a sort of wave ran up the wriggler, but with the added peculiarity that the farther the disturbance traveled the greater was the number of cross-bars affected. The disturbance, which was represented at the bottom by a sharp jerk affecting one bar only, had thus spread over a dozen or more before it reached the top.

A still better illustration, the lecturer proceeded, of the principle involved was afforded by waves on the surface of water. If a stone were flung into a pond, rings spread out from the center, which became more and more numerous as the distance from the origin increased, so that, quite far out, beautiful wave patterns could be seen over a large breadth of water. Lord Kelvin had, Sir Joseph proceeded, worked out the theory of such disturbances. Taking a disturbance represented by the heaping up of the water into a single hump at one point, he had calculated the form of the water surface after the lapse of different intervals of time. The results are represented in the subjoined diagrams and show that, as time went on,



the disturbance took more and more the ordinary wave form, the original isolated hump being replaced by a series of waves. The wave-length of these waves was, moreover, greater the farther the distance from the origin. In short, the original hump broke up into distinct series of waves, with the longest waves in front, and we thus got regular wave patterns produced by a simple splash. The general result was that any irregular disturbance communicated to a water surface was automatically sorted out into regular series of waves, the number of which depended upon the distance traveled. A prism, on receiving an irregular light pulse, behaved in an analogous way. The irregular pulse of light was spread out by the prism into an immense series of perfectly regular waves, the number of which depended on the distance traveled in the prism and had little to do with any regularity in the vibrator in which the pulse originated. This action of a prism was, he went on, due to the fact that the velocity of light in a dispersing medium depended on the wave-length. The easiest way of considering the matter was to analyze the original disturbance into a series of waves by means of Fourier's theorem.

Fourier had proved that any kind of disturbance whatever could be represented as a series of regular waves superimposed one on the other. This held even were the disturbance equivalent to an abrupt noise.

In fact, any noise whatever could be reproduced by striking, suitably and simultaneously, a series of tuning-forks of different pitches. Each of these forks emitted its own musical note, and by simultaneously striking the appropriate forks, any noise, no matter how abrupt and discontinuous, could be reproduced. Further, it was possible to have the forks all in motion for some time, with resultant silence, and for them then to give an abrupt noise and to subside into silence again, while still continuing in motion, the silence before and after the noise being due to the mutual interference of the effects due to each individual fork.

The initial "hump" on the water surface in Lord Kelvin's problem could accordingly be considered as made up by the superimposition of waves of different wave-lengths. A peculiarity of water and of glass and other dispersive media was that the speed of wave transmission depended on the wave-length. In the rubber tube used in the first experiment shown, the speed, on the other hand, was the same whatever the wave-length, and this was also true of sound-waves in air, so that a tune played by a band was heard as a tune whatever the distance of the auditor. The waves into which the hump could be resolved all traveled along the rubber tube at the same rate, and the disturbance accordingly retained its shape, as had been seen. In the case of water, however, the series of waves, into which the initial hump could be resolved, traveled with different velocities, those of longer wave-length traveling faster than their shorter fellows. Hence at the front of the disturbance resulting from the subsidence of the hump, long waves predominated, and the shorter waves were left behind. The farther away from the center the greater was the separation, and possibly, if one could get far enough away, the leading waves would be accurately "monochromatic."

To show how the waves corresponding to an abrupt disturbance of a water surface could be analyzed, the lecturer exhibited the following experiment: A thin stream of water was allowed to run down an inclined sheet, and a reflection of its surface was thrown on to a screen. An obstacle in the path of the water caused a disturbance of the surface, and this disturbance could always, whatever its nature, be represented by the superimposition of a number of waves of different wave-lengths. Among all these waves there would be one series traveling upstream with the same speed that the water surface was traveling downstream, with the result that stationary waves were produced, the reflection of which was very evident on the screen. The waves in this case were due to surface tension, and not to gravity, which was, however, responsible for ordinary sea-waves. Waves due to surface tension traveled the more rapidly the smaller the wave-length, and were known as "ripples," while in the case of waves due to gravity it was the largest waves which traveled fastest. By increasing the speed of flow the lecturer showed that the pitch between successive crests of the ripples was shortened, since at the higher speed it was a component with a shorter wave-length that moved up-stream as fast as the water flowed down. By reducing velocity of flow, a point was reached, the lecturer showed, at which all signs of wave action disappeared. This was, he remarked, due to the fact that there was a certain minimum speed for the propagation of waves over a water surface.

The experiment just described showed, the speaker said, that by the action of the transmitting medium in selecting waves moving at a certain speed, we got a regularity which was quite independent of the exciting source. The phenomenon exhibited corresponded very closely with the action of the glass of a prism on light.

* Engineering.

No matter how irregular the disturbance entering the glass might be, it would be sorted out by the glass into perfectly regular series of definite wave-lengths.

It would be evident, the speaker continued, that the action of a prism in producing a spectrum was thus more fundamental in character than was usually supposed, so that the prism actually "colored the light." In fact, apart from an action of this kind, it was difficult to see how a very short disturbance could in any circumstances produce the sensation of color. There was, in fact, no conceivable mechanism by which a disturbance lasting for only a fraction of a vibration could be distinguished as a color by the eye. For this to be possible it would seem necessary that at least two or three complete vibrations should be received, just as in music it was necessary for the ear to receive two or three complete vibrations if it were to distinguish the note. He held this view, he said, in spite of some statements which had been made to the contrary.

Hence, if a thin pulse of light, not lasting as long as a single vibration in the luminous spectrum, were received, it would not give the sensation of color. On passing through a prism, however, a short disturbance of this kind would be lengthened out, and by having the path long enough as many vibrations as desired could be obtained. The prism, therefore, did much more to the light than it was usually credited with, at least in the older text-books on optics. In these, the view expressed was that the colors existed as a mixture in the incident white light, and the action of the prism was simply to disentangle these. From a purely mathematical standpoint this view was tenable, as a pulse, however sharp, could be considered as the resultant of an enormous number of vibrations. Physically, however, the action of the prism was not merely to split up these colors, but to prolong the time during which a disturbance lasted. This effect depended on the length of the optical path, and the number of definite waves produced from a sharp pulse was proportional to the length of this optical path.

From this point of view it would be seen that a study of light passed through a prism could give no certain indication as to the nature of the vibrator in which it originated, any more than could the light from a grating be taken as a conclusive criterion of the regularity of the source.

There were, however, some cases of interference which stood on a different footing. Michelsen's interferometer, for example, comprised nothing corresponding to a grating, and though lenses might be embodied in it, the optical path in these was not nearly long enough to account for the result observed.

Using this instrument, Michelsen had obtained interferences between waves of mercury light, the lengths of paths of which differed by more than half a million wave-lengths. The significance of this observation might, he proceeded, be made clear by considering a corresponding case of interference by sound. Take, for example, he said, the case of a sensitive flame backed by a glass reflector. Then, if a sound were emitted from a suitable source, the flame would respond to the disturbances reaching it. Of these the one came direct from the source, while another reached the flame after reflection at the glass plate, and this reflected disturbance had traveled a longer distance than the direct wave. By suitable precautions matters might be adjusted so that the action of the one wave cancelled that of the other, and the flame remained unaffected accordingly. The point to be noted was that the reflected wave, having traveled over the longer distance, must have started from the source some time before the direct wave which it annulled. The longer the difference between the two paths the greater must be the time which had elapsed between the emission of the two interfering disturbances. In Michelsen's experiment, interference was obtained between rays, although the source emitted the one ray 540,000 vibrations after it had sent out the first ray; nevertheless a counterbalance was still obtained. This observation was usually taken to imply that an atom of mercury could sustain vibrations with such persistency that after a half a million of them it was in action as vigorously as ever, and was, moreover, radiating all this time without any change of phase. This appeared hardly probable to the speaker. He did not, in fact, find it easy to realize how the necessary conditions for the interference could be sustained if the whole of the radiation was produced by a single atom. Such atoms were, for example, continually coming into collision with other atoms, and the consequent shock would alter the phase of the radiation emitted. It appeared, however, on making the appropriate calculation, that disturbances thus arising were unimportant, as the interval between successive collisions was very large in comparison with the time occupied in emitting half a million vibrations. A radiating atom was however also subject to shocks of another kind, as each was surrounded by others also emitting light, and to this light the atom was very absorbent. If it did pick any up, however, it would be thrown out of step, and the regularity necessary for interference effects would be destroyed. We should have, accordingly, to suppose that each luminous particle of mercury, during the time it was luminous, received no light. Such a supposition would, however, be inconsistent with the number of luminous centers present.

What really happened appeared to be that the necessary precision of phase was produced by the action of the light itself. The light that interfered was, in short, not derived from a single luminous center, but from a considerable number of such centers forced into phase by their mutual inter-action. It would seem that the stream of green light, in passing the atoms of mercury, excited them to radiate in phase with itself by fixing the time at which a particular atom began to be luminous, firing it off, as it were, in phase with itself. This phase was accordingly forced upon the active atoms. As one ceased to radiate another began, and the phase at which it started was fixed by the stream of light in which it lay. Some view of this kind was, he thought, necessary to make intelligible interference between rays having a difference of over half a million wave-lengths in the paths traversed.

(To be continued.)

The Extension of Human Life*

By Irving L. Fisher, Ph., D.

While we are already agreed that human life is extensible, we are not so fully agreed as to the best methods to be employed for extending it. In fact, for several years a few students have been suspecting that the work of prolonging life—as it is at present being conducted—is not pursued in the most effective manner, and that, in particular, we are neglecting one of the most, if not the very most, promising means of all—individual hygiene.

Our present methods have their roots, for the most part, in the work of Pasteur. Ever since Pasteur made his epoch-making discoveries and uttered his inspiring words, "It is within the power of man to rid himself of every parasitic disease," health workers have sought to secure their results almost wholly in the single direction which he indicated, i. e., by attacking our infinitesimal parasitic enemies.

In the *Report on National Vitality*, of the Roosevelt Conservation Commission, a summary of European life tables shows that human life lengthened during the seventeenth and eighteenth centuries at the rate of only four years per century, and that during the first three quarters of the nineteenth century it lengthened about twice as fast, but since that time it has been lengthened more than four times as fast or about seventeen years per century.

These figures would seem large enough to satisfy the most ambitious, and certainly, if life could continue to lengthen, at the rate of seventeen years a century, after a few more centuries the world would be populated mostly by Methuselahs.

But our prospects are not so bright. In fact, there is a large element of gloom. When we analyze the present improvement, we find it is due chiefly to a decreased loss of life from infection before middle age, in spite of an increased loss of life after middle age from degeneration. Such a process bids fair soon to change our net gain in the average life span into a net loss, but the truth is, we are witnessing a race between two tendencies, a reduction of the acute infectious diseases, such a typhoid, and an increase in the chronic or degenerative diseases, such as arteriosclerosis and Bright's disease. By degenerative diseases are meant those which consist in the degeneration or wearing out of the vital organs.

This degenerative tendency seems to be more in evidence here than elsewhere. In Sweden we find the expectation of life increasing at all ages. There, even the nonagenarians of to-day have more years to live than did those of former days in the United States.

The fact seems to be that while we are freer of germs than our ancestors, our vital organs wear out sooner. The degeneration of our bodies follows a degeneration of our habits. It is especially significant that in England, where the diseases are not increasing, individual exercise, out-of-door sports for the masses, and self-care are, apparently, not declining, and it is still more significant that in Sweden, where there is improvement at all ages, the interest in individual hygiene is the greatest in the world. It is the only country where public health includes private habits and touches the life of the people, especially through the public schools.

Strong corroboration of the decadence in our health is given by the experiences of the Life Extension Institute. Its chief work at present consists of medical examinations, to discover possible physical impairments. These medical examinations are made partly for life insurance companies. They constitute the first general physical survey of sample groups of our citizens and reveal conditions of impairment which are truly astounding. They include about 2,000 medical examinations of employees of the commercial houses and banks in New York city among young persons, mostly young men, with an average age of thirty.

These figures are especially surprising because of the large number of young men and young women suffering from diseases of the heart, kidney, and circulatory system. The fact of great import, however, was that impairment sufficiently serious to justify the examiner in referring the examinee to his family physician for medical treatment, was found in 59 per cent of the total number of cases!

In other words, considerably over half of the young men and young women in active work, and presumably selected for their work as especially "fit," were found, although unaware of the fact themselves, to be in need of medical attention, while 37.86 per cent were on the road to impairment because of the use of "too much alcohol" or "too much tobacco," constipation, eye-strain, overweight, diseased mouths, errors of diet, and other ailments.

It would seem that to-day men and women begin to die almost as soon as they are grown up, but are dying so slowly that neither they nor their physicians suspect the process, until death stares them in the face. What would we think if such a per cent of impairments were found in a dairy, or a flock of sheep!

On the principle that "a stitch in time saves nine" the early diagnosis and prompt treatment, in the incipient and easily curable stages of the degenerative diseases, should be the next great step forward in the fight for improving national vitality.

No factory owner would allow his machinery to go uninspected until it broke down. Yet that is precisely what we have done with the human machine. Worse still, we have scarcely studied, much less advocated, those simple rules of hygiene, by which alone the degenerative diseases can be prevented. We need to know more of what errors we may be committing according to the laws of physiology.

Is our diet, for instance, too acid and too litle alkaline? Do we take our food too concentrated? Are the common drugs we use in beer, cigarettes, tea and coffee, seriously harmful? These and numerous other questions are not yet settled in our minds because most physicians and health officers have not yet seriously concerned themselves with them.

The old idea of the ancient Greeks, of cultivating a sound mind in a sound body by the exercise of simple personal hygiene through the proper use of air, food, rest, exercise, bathing and wholesale recreation, was utterly forgotten during the middle ages, when, in the quest for spirituality, the absurd doctrine was promulgated that the flesh is gross and in league with the devil. Medieval artists associated saintliness with sickliness and chose consumptives for their models.

We need to formulate scientifically what constitutes a wholesome life and to educate the public on what changes from existing customs are necessary to live that life. Furthermore, in the industrial world we must in some cases compel wholesome physical and mental conditions for our working people. The time has come when science must subdue custom and reason triumph over tradition.

* From *American Medicine*.

Improving Negatives for Printing

Negatives which, from faulty development or other causes, are more or less imperfect in some parts may be considerably improved in many ways. For instance, suppose that the subject is one in which a heavy mass of foliage occurs in the foreground, together with a well-lit distance. Now in order to represent the distance correctly in the negative the foreground in many cases is almost entirely devoid of detail, and is shown in the print as a heavy black mass. In such a case, if the negative is coated (on the glass side) with matt varnish, containing a small amount of iodine dissolved in it (the quantity depending upon the circumstances of the case), heavy shadows in negatives can be made to print much lighter and the results improved to a great extent. The varnish, after it is applied, will dry in a few minutes, and then over the parts not required to be lightened it is removed with a penknife or a piece of rag, moistened with a little methylated spirit or benzole. The same means may be applied in the case of protraits and groups, only greater care is required in scraping away the varnish from the parts where it is not needed in order to prevent any marks from showing. Portraits taken out of doors frequently show very heavy shadows under the eyebrows and chin: these may be considerably lessened by applying a little color (either red or blue) on the glass side of the negative, and then dabbing it with the finger, so as to form a kind of stipple caused by the texture of the skin. If carefully applied, the method is very satisfactory, and will tend greatly to reduce the heaviness of such shadows.—Edgar Senior in *Knowledge*.

Reducing Our Waste in Eggs*

What the Demonstration Car of the Department of Agriculture is Doing

By M. E. Pennington, H. C. Pierce, and H. L. Shrader

A LARGE refrigerator car, painted white, and bearing on its sides the inscription, "U. S. Department of Agriculture, Poultry and Egg Demonstration Car," was backed down a railway siding in a typical Southwestern town and came to a stop about two blocks from the station. There it remained while the heterogeneous mass of freight cars to which it had been attached rumbled slowly away, to disappear in the north. Two men carrying sweaters that seemed strangely out of place with a temperature that particular morning in the neighborhood of 105 degrees in the shade came toward it from the station, unlocked the door, let down a flight of steps and entered. A moment later came the regular throbbing of a gasoline engine, the whir of large fans could be heard, and incandescent bulbs began to flood the interior with light. The men put on their sweaters, for it was suddenly getting cold.

The Department of Agriculture's demonstration car was now ready to begin its daily business of trying to reduce the $50,000,000 annual waste in eggs. Part of this loss can be debited to needless breakage of eggs in transit from the nest to the retailer. The balance represents the unnecessary addling, spoiling and deterioration of good eggs that comes from bad handling on the farm, on the way from the farm to the town, in the town, in transit from town to city, and in all stages of progress from the carload lot to the breakfast table.

The importance of the loss of eggs which has occurred by the time the product reaches even the country shipping centers can be seen from reports of twenty prominent shippers in a single egg-collecting point. These men reported that one year the percentage of eggs which arrived in a state so bad that they were an absolute loss rose to 8.33 per cent in November, with a mean loss for the year of 4.36 per cent for the 32,730 dozen eggs, or over 1600 cases, which were specially examined. The loss in eggs between the time the hen lays a fresh egg and the time when that egg is traded or sold to the country merchant may be judged, also, from the fact that a special inquiry conducted among country storekeepers in October showed that only 25 per cent of the eggs they secured from the farmers would rank as "firsts," and that 60 per cent were "seconds," due to long holding on the farm; that 5 per cent were cracked, and that 4 per cent were rotten or stuck to the shell.

Reports had reached the Department of Agriculture that the shipments of eggs at this particular time from the Southwest were showing far more than the normal number of "floaters," "blood rings," "white rots" and "black rots," which are terms employed in the egg-handling trade to represent the different stages of descent from a good egg into a very bad egg; and instructions began to go out from Washington: "Send the egg car to central Texas and travel north during May." In response to these orders the car was delivered at this particular station on a hot May morning, and thus was added another fraction to the 7,000 miles the car has traveled during the last two egg-laying seasons on its egg-saving mission in Kansas, Oklahoma, Texas, Arkansas and Missouri, the corn States which produce a vast proportion of the eggs consumed in the great cities of the East.

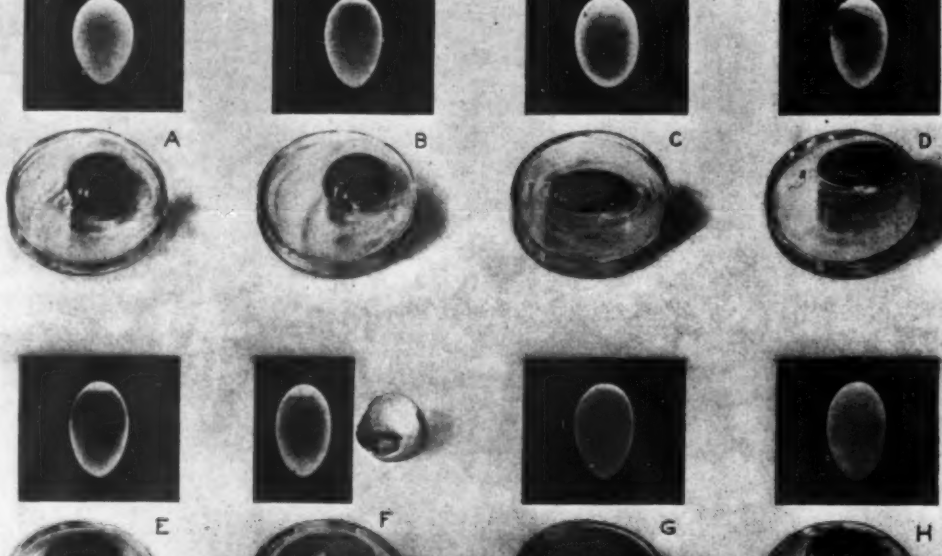
The demonstration car is fitted up to be an egg packing and chilling establishment on wheels. In one end is an ice bunker holding over three tons of ice, and at the other end is a good-sized gasoline engine for running the cold-air fans and driving the dynamo which supplies light. By means of false walls running from the ice chamber, the fans are able to drive chilled air to all parts of the car, and thus make possible the proper precooling of eggs for shipment, and the testing, packing and handling of eggs at temperatures which prevent or delay spoiling.

The chilling of eggs is almost the beginning and end of keeping New York and other great cities supplied. Heat is the great enemy, for once a good egg has stood for any time at a temperature of over 68 deg. Fahr. it begins to incubate, if it is a fertile egg, or to spoil, if it is an infertile egg. For this reason the car is equipped to give a practical demonstration of the advantage of keeping eggs cold and chilling them thoroughly before starting them in refrigerator cars on the long haul from the corn belt to the great egg-consuming centers.

In another section of the car are two egg-candling rooms, supplied with electric lights, equipped for candling eggs by being inclosed with dark coverings in which there is a single hole the size of a half dollar. In these dark rooms the experts hold the egg before the candling light, and its condition is instantly revealed with almost photographic clearness. The purpose of candling eggs at home, of course, is to decide which of the housewife's dozen is in perfect condition for breakfast or cookery. On the commercial scale, the testing is to determine not merely whether the egg at the moment is good for immediate consumption, but whether, if properly chilled, packed and handled, it will survive a long shaking up on a 1,000-mile railroad trip and remain good in transit, storage and the retail store until it reaches a distant home. For unless an egg starts on its journey in absolutely good condition, no amount of refrigeration or careful handling will restore it to goodness. And the egg that has begun to deteriorate, that shows the first sign of the incubation of its germ, spoils rapidly every hour that it is subjected to ordinary summer temperatures—in fact, every minute that the fresh-laid egg spends in the nest or elsewhere, exposed to more than 68 deg. Fahr. starts it on a downward career. As the temperature mounts, the egg approaches hatching conditions. At 102 deg. Fahr. it might as well be in an incubator or under a hen.

To assist those who are not experienced candlers, the Government has printed carefully colored lithographed charts, which show the exact appearance of different grades of eggs before the light. With this chart the egg dealer and even the housewife is enabled to candle eggs with sufficient accuracy.

The absolutely fresh egg held against the light shows a distinctive pinkish glow of goodness. Let that egg, however, remain out in the sun or in the summer heat for a little time, and within a day or two it begins to show "blood," a tiny series of little blood vessels forming around the embryo of the chick; or the heat may cause the yolk to go toward the top and shift easily, which characterizes it as a "light floater." Again, the yolk may mix with the white and make a "white rot," a condition also revealed by the candle. The final stage is the "black rot," where no light at all can be seen through the egg. The egg has now reached the explosive stage, which makes it such a favorite missile of the average boy. There is, however, another type of bad egg which most people would think good for food. The yolk is a firm golden ball and the white a clear liquid. But the white has a greenish color—and the green indicates that the egg is full of bacteria—it is a "green white egg."



An egg chart illustrating various defective conditions.

A, A fresh egg, before the candle, and out of the shell. *B*, Slightly stale egg, showing evidence of incubation. Before the candle, and out of the shell. *C*, Stale egg, showing a settled, flattened yolk and a thin white. Before the candle and out of the shell. *D*, Yolk beginning to adhere to shell. *E*, This shows a blood ring. *F*, Cracked egg invaded by mold. The shell shows mold inside. *G*, White rot or addled egg. *H*, Egg with green white.

A perfect shell is one of the essentials of a good egg, because any crack or break in it will tend to let in all sorts of bacteria to hasten its putrefaction. The egg, therefore, must be graded not only by the condition of its contents, but by cleanliness and soundness of shell as well. An egg that is so badly cracked that its contents escape is termed a "leaker." A "leaker" not only will not keep itself, but it may soil and injure a large number of eggs packed in the same case with it. They are thrown out, therefore, at every stage of handling, and constitute a total loss. "Checks" are eggs the shells of which are cracked, but the membranes still intact. These, too, are sure to rot quickly. The egg with a dirty shell, no matter how good its contents may be, does not bring a high price on the market. Washing eggs, however, hurts rather than helps them, for the reason that any water put on an egg washes off some of the protective covering which the hen puts on the shell to make it more resistant to the entry of germs. A washed egg is shiny and smooth looking, and lacks the powdery bloom of a clean, fresh egg that has not been washed.

For the woman of the farm, each good egg in its shell is practically so much cash. In fact, eggs and chickens supply a large proportion of what might be called the ready spending money of the farm woman. The local merchant pays her for her eggs either in money, or else immediately transforms the eggs into calico or shoes or groceries. The country storekeeper similarly regards the eggs as money, and deposits them with the local egg collector and shipper, who honors the poultry check and turns back the cash to the storekeeper. From this point of view the local egg shippers might be regarded as running an egg bank.

The doctrine taught is not especially altruistic, for the local egg man or farmer owes no philanthropic or social duty to a distant consumer. The argument is entirely one of dollars and cents in the pocket of the farmer and his wife, the local egg-commission man, and in the general pocket of the county itself.

"Thirty per cent of your eggs are wasted. You are getting 30 per cent less money for your eggs than you ought to be getting. It isn't a question of tools or money

*Year Book of the U. S. Dept. of Agriculture.

or capital. It is a question of care and intelligence which cost nothing but a little time. Come to the car and learn how to save $1,000 a week in rotten eggs."

If the egg car, with its doctrine of egg conservation, reached only the collectors, it could save but a fraction of this waste. Eggs do not stay good as long as they are in the country and suddenly become bad when they come to town. An egg is full of original sin from the moment it is laid, and asks only for a little leisure in a warm place to indulge in all its proclivities for wickedness. The morning laying, if left all day in the heat or in a hot hen-house over night, will begin to develop the hatching germ. Good, fresh eggs put in a basket and stored in the hot kitchen for a day or two may reach town in such condition that they must be used at once to be available for food. A basket of perfectly fresh eggs left in the back of the wagon and exposed to the sun during a 10-mile drive to town may reach the country merchant in such shape that not even immediate chilling will make them available for long shipment to the cities. This is the story constantly revealed by the candle on the egg car. It is evident, therefore, that if the egg is to be palatable to the city consumer, care in its handling must begin on the farm.

The effort is principally to get the farmers themselves to candle and grade their eggs before they start for town, and then to offer the buyers their eggs on a quality basis. This means that the farmer offers so many dozen of fancy eggs at a certain price per dozen, and so many other eggs of different grades at smaller prices. Under this plan the farmer quickly finds that he makes more money by selling his eggs according to quality than when he simply sells them at an average price per dozen, which the buyer has to make low, in order to cover himself against off-size, off-color, dirty, cracked, checked or deteriorating eggs. If the farmer has one dozen of 17-cent eggs and another dozen of 13-cent eggs, he gets 30 cents for his two dozen, whereas under the other basis he probably would get only 13 cents a dozen or 26 cents for his basket. In the absence of a quality basis of buying, the buyer either simply pays a lump sum, gambling on the quality of the eggs, and naturally fixing a very low price, or buys on a "loss off" basis, which means that he deducts from the farmer's returns all the bad, leaking or unmarketable eggs found in his offering. In either event the farmer has had the trouble of bringing worthless eggs to town, and does not get the benefit of the high price that would be paid for the percentage of strictly good eggs in his basket.

Quality buying is equally important to the local storekeeper and small-town egg collector. This was illustrated one day at the car. A dealer who bought on the case-count plan—that is, paid a flat price per dozen for the eggs, whatever their condition—brought a lot of 10 dozen eggs and asked that their quality be determined by candling. He had paid 13 cents a dozen for the eggs, and the candle showed that only eight dozen could be rated either "firsts" or "seconds." The remaining two dozen were so bad as not to be marketable under any grade. The buyer figured gloomily that he had paid about 16 cents a dozen for a mixture of "firsts" and "seconds," or 1 cent above the market price for "firsts."

In connection with the candling demonstration, the demonstrators of the car take particular pains to show each visitor, by means of photographs and actual eggs, the difference in the keeping quality between a fertile egg and an infertile egg, or one that is laid by a hen in a roosterless flock. The fertile egg, because of the chick germ in it, deteriorates very rapidly as soon as it is allowed to get warm. This deterioration appears as blood on the yolk, which is the first very noticeable evidence of the incubation of the chick. The next stage is the formation of the blood ring—a circle on the yolk—which appears when the embryo dies. The infertile egg, which contains no chick germ, will, of course, deteriorate if allowed to get warm, but as there is no germ to hatch, no "blood ring" develops and the physical changes in the contents are very much less marked, and the chemical changes which would make it inedible go on much more slowly. The infertile egg, therefore, will keep very much better and is a better product to put in cold storage for winter consumption. State poultry officials and the dealers in many cities encourage the farmers to remove roosters from their flocks after the season in which eggs for hatching are laid. This movement is aided by the fact that after the hatching season the dressed poultry and egg dealers frequently offer the farmer an attractive price for the roosters, which are then dressed and sent to market. The farmer gains from not having to feed the rooster, the absence of which makes absolutely no difference in the laying of the hens. The infertile egg, moreover, is just as nutritious and desirable for food as the other.

The cold-storage plant in the car is designed for proving to the egg receivers of the towns the importance of chilling eggs to a temperature below 50 deg. Fahr., before they are shipped in refrigerator cars to the large cities. While this process would be of advantage if begun on the farm, it is realized that few poultry raisers can afford ice enough or the cost of even a small refrigerating machine for thoroughly chilling eggs. Instruction to the farmers in keeping eggs cool, therefore, is largely limited to such practical methods as storing in refrigerators or in the cooler places on the farm, such as the spring house, cold cellar, or ice house. Where none of these methods are available, the farmer is urged to gather his eggs quickly after they are laid, and keep them ever after out of the direct heat of the sun. Figures show how ordinary eggs, by means of a local refrigerating plant, can be brought down in 24 hours to the temperature at which they can safely be shipped. Eggs prechilled to this temperature remain at the safety point in the refrigerator car, instead of having to travel for two or three days at dangerous temperatures until the ice in the refrigerator car can chill them.

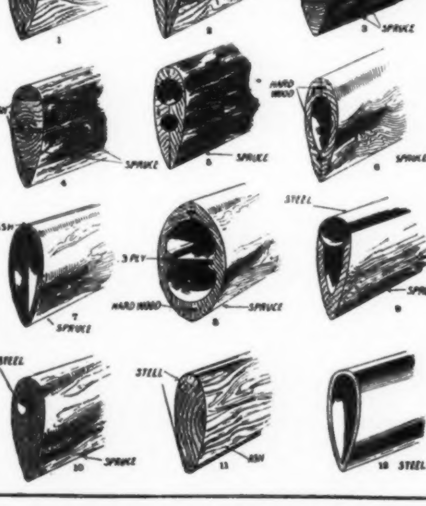
Another portion of the car, which is kept cool by the air blown from the ice bunkers, has been made into a small packing room, where cases can be filled and properly nailed for shipment, to show the egg shippers the safest way of preparing their product for the jolting it must receive in freight cars. The importance of this work is indicated by a recent study of the breakage of eggs in transit. According to this investigation, on an average of 24 eggs out of every 30 dozen packed in a case arrived at market either cracked, dented, leaky or mashed. These figures represent the detailed examination of 6,000 dozen eggs before and after shipment, and the results of a general study of the condition of 71 carloads of over 500,000 dozen eggs shipped in car lots from 36 packing houses in the corn belt to 10 different markets on the Atlantic coast. They mean that New York city alone has a breakage of 116,000,000 eggs annually.

The number of eggs broken in transit, it is believed, could be greatly reduced if only sound, new cases were used, proper packing employed, a proper system of nailing on the covers followed, and an efficient method of stowing and bracing the cases in the car practised. A study of egg cases has established exact facts as to thickness of the wood, and has shown that there is a right and a wrong way to drive every nail employed in putting the case together. The specialists have determined that a cement-coated nail will hold better in an egg case than a smooth nail; that the use of less than six nails in closing the case greatly increases its chance of straining, and that nails driven in straight make the box much more rigid than nails carelessly driven at an angle.

The way in which the eggs are packed inside the crate is also very important. Many experiments have shown that the fillers, or little cardboard cells in which the eggs are put, must be new and strong, and that the flats, or cardboard sheets placed at the bottom and top of each case and in between the layers of eggs, must be springy and unbroken. Much of the breakage in transit is due, not to unusually rough handling by the railroads, but to neglect of these simple facts.

Aeroplane Struts

The shape of the various struts of an aeroplane are determined principally by aerodynamic considerations. As a good streamline section may be weaker laterally for a given weight than an inferior streamline form, the



How streamline struts are built up.

great effort is to shape and combine suitable materials so that a strut may be fashioned which shall have sufficient strength without adding to weight. In other words, the trend of mechanical ingenuity in this direction, as indeed in all pertaining to the aeroplane, is to perfect combinations which shall increase the strength while decreasing the weight.

Sketch No. 1 shows the simplest form of construction, where the strut is machined from a solid piece of wood, the kind selected being determined by the purpose to which the strut is to be put.

No. 2 sketch shows a strut that is formed from two pieces of wood glued together. The method generally employed is to saw the piece from which the strut is made lengthwise and then to turn one of the pieces around end to end. The effect produced is obvious, the reversing of the grain giving an added degree of strength.

The next step in the evolution of the strut is shown in sketch No. 3 where the nose and the tail are made of ash and the center piece of spruce. In this there are three pieces in the strut, instead of two as in the preceding illustration.

But in No. 4 the number of pieces is increased to five, though there is no radical departure from the manner of assembling them. The nose piece, the center piece, and the tail are of ash, while the remainder of the strut is made of spruce.

In the foregoing class the struts are necessarily heavy and, in consequence, they are employed principally where the member is subjected to a heavy load or a severe shock. Such struts are used in the undercarriage for inter-plane struts joined to the lower wing at the point where the chassis members are attached, or in machines where the undercarriage is secured to the lower wing instead of the body.

In designing the lighter form of struts there are three courses—reduce the depth and thickness of the types just discussed, and of course the limit is soon reached in that direction, or to use larger sections and hollow them out, as Nature does in a reed, or to employ metal in combination.

It will be seen that in the strut shown in No. 5 the formation is in two pieces. Two grooves are made in each portion of the strut, leaving the center untouched, and they are then joined together. The transverse web thus formed very materially strengthens the strut against lateral buckling.

In No. 6 the two halves are joined together by means of a fillet of hard wood.

No. 7 is a longitudinal web of ash to which is joined two pieces of spruce.

The distinguishing feature of No. 8 is the transverse web formed by a strip of three-ply wood set into recesses in the sides of the strut. In this strut, as in the other combination forms referred to, the pieces are glued together.

The final four illustrations are combinations of wood and metal. No. 9 is a steel tube to which is attached at intervals by means of bindings a fairing of wood. In the No. 10 illustration the steel tube is inclosed wholly within a strut of spruce roughly conforming to the simple form shown in the No. 1, while in No. 11 the nose and tail of the strut are formed by steel tubes, not quite closed on one side, and which are pushed into grooves in the wood.

When all-steel construction is used it generally takes the form of a cold drawn steel tube that may be either elliptical or in the form herewith shown in the final illustration.—*Flight.*

Extinction of Species

Many suggestions have been made in regard to the causes which bring about the extinction of species. In some cases perhaps the times change, and highly specialized creatures are not plastic enough to change with them. Sometimes the invasion of a territory by some new enemy involves the doom of old-established tenants. According to some authorities, species grow old as individuals do. Sometimes the answer is simple enough, for man's ruthlessness is to blame. The subject has been recently discussed by Prof. V. Hensen, who holds that the death-blow may be often due to inbreeding and the associated accumulation of harmful by-products. In this connection he refers to the case of the rainbow trout (*Trutta iridea*), which was brought to Europe from California about 1880. For a while it flourished well, and seemed very resistent. Gradually, however, it lost its grip. The germ-cells of both sexes degenerated before complete maturity, and diseased conditions became common. The liver cells, for instance, became encumbered with fat, and the secretion of bile was interfered with.—*Knowledge.*

Gas-filled Tungsten Glow Lamps

Instead of a vacuum, the space surrounding the filament of tungsten in these lamps is filled with gas. Nitrogen is used in the larger sizes, and argon in the smaller. For small lamps the gas has to have a low thermal conductivity. Therefore argon was used in preference to nitrogen. But it was found to be desirable to add a small admixture of nitrogen, since argon had no great power of resisting electrical discharge, and lamps filled with pure argon were liable to short-circuits.

The Bagdad Railway and the European War*

Progress Made Up to the Outbreak of the War and Present Lack of Materials

By Lewis R. Freeman

The idea of a railway to the Near East and India has been in the minds of the British ever since railway building became general, 60 or 70 years ago, but thanks to political jealousies, up to five years ago that project was no nearer consummation than when it was first talked of. Even now the only line which is well advanced India-ward is the Bagdad Railway, and that, being built and largely controlled by Germany, will never be acceptable to the British, even as a link in an intercontinental system. At the outbreak of the war plans were, to be sure, well advanced on what is called the Trans-Persian Railway scheme, by which England and Russia would build a line starting from the terminus of the Baku Railway at Aliat and crossing Persia and Baluchistan to the Indian frontier and on to Karachi. The project, however, like every other piece of international railway construction in Asia, is in the political crucible, and in what shape it emerges depends upon too many hair-trigger contingencies to allow much hope that anything tangible will come of it. A change of government in England, or any modification of the present *entente* with Russia, would be almost certain to operate to stop work on such a line, should it ever be started, or even to force a discontinuance of traffic in case it was completed and opened. All of this because political rather than commercial considerations must, for many years, govern the building and operation of any railway built between Europe and Asia—except, of course, in the case of Russia, which has adjoining territory in both continents.

Up to the outbreak of the war patriotic Britons were having much to say regarding what they called the "All Red" route to India. This railway would start at Port Said or Cairo and run almost directly east across northern Arabia to Bussorah or Koweit, at the head of the Persian Gulf, and then down the east side of the gulf to Baluchistan and Karachi. As Arabia is practically under British domination, and southern Persia falls within the British "sphere of influence," this line deserves the title of an "All Red" or "All British" route. There are several obstructions, however, the combined weight of which will undoubtedly prevent the consummation of the project for many years. In the first place, its western terminus at Port Said is in Africa, not Europe, and it would not, therefore, fulfill the main consideration of a trade route between the latter continent and India. In the second place, the portion of Arabia to be traversed has never been surveyed, and though there may not be any prohibitive engineering difficulties, the water problem over so long a stretch of desert would be a serious one, while the controlling of the fierce nomad tribes would require practically an armed occupation of the country. Third, and most important, Turkey and Germany would have to be very thoroughly crushed in the present war before granting a concession which would practically amount to severing the whole peninsula of Arabia from the rapidly dwindling Ottoman Empire.

There is only one entirely favorable route for a railway from Europe to India, and that is one which would follow the present line of the Bagdad Railway to the city of that name, continue down the Tigris to a point near the end of the Persian Gulf, and then skirt the eastern shore of the latter to the Indian frontier. In permitting Germany to oust her as the dominant influence at Constantinople, England suffered the most serious of several costly defeats which have fallen to her lot in the diplomatic skirmishes of the Near East in the last decade, and the passing of the Bagdad Railway concession to Germany is a part of the price. This route is not only by far the most direct one between Europe and India, but practically all of the 1,300 miles of its length between Konia and Bagdad lies through a region which may very fairly be characterized as one of the richest undeveloped stretches of agricultural country in the world to-day. This also holds true of the several hundred miles of rich delta between Bagdad and the head of the Persian Gulf, leaving the only desert to be traversed that of southern Persia and Baluchistan, which will have to be crossed by any line from Europe to India. The trans-Persian route, to which Great Britain—partly through a desire to placate Russia and partly through lack of a better alternative—now stands committed, will run through desert, once it has left the narrow zone of cultivation in northern Persia, all the way to India.

When the Bagdad Railway scheme was first brought up, the Ottoman government invited Great Britain, France and Germany to share equally in its construction. France and Germany responded favorably at once, but ill-advised attacks on the project in the British press were responsible for keeping England from coming in, and, ultimately, for the withdrawal of the French. The Germans assumed full control. The concession provided for the construction of a standard 4-foot 8½-inch gage railway from Konia, the terminus of the Anatolian Railway from the Bosphorus, *via* Aleppo, the capital and metropolis of Syria, and Mosul, on the site of Nineveh, on the Tigris, to Bagdad, the Bagdad Railway Company—a German concern with headquarters at Frankfort—to furnish all materials and do the work, for which the Ottoman government pledged itself to a certain guarantee per mile. Just what the latter figure was has not been made known. French and British officials in Aleppo and Bagdad assured the writer that it was far more than the work would cost and that its payment would tie up the revenues of the government for many years to come. Meissner Pasha, the general manager, and several other officials of the Bagdad Railway, however, claimed that the guarantee might hardly cover the cost of construction, and that such profits as were realized would come through the use of German materials. This might easily be true, as the price of labor and food have more than doubled in the decade since the Bagdad Railway concession was drawn up, and a guarantee which would have allowed an ample margin of profit at that time might not prove sufficient to cover the actual cost of construction at the present. The political ascendency incident to the construction of such a line was sufficient to induce the German government to endeavor to see through its construction in any case.

Work was being pushed at a dozen points on the Bagdad Railway at the outbreak of the war, and up to that time it had been the expectation that trains would be running from the Bosphorus to Bagdad by the middle of 1917. The war accelerated work in one way, and in another retarded it. Unquestionably the Germans have made a supreme effort to hasten construction by employing increased construction gangs, but it seems certain that shortage of structural materials must have a good deal more than out-balanced anything that could be done in this way.

All the materials for the Bagdad end of the line were being brought by ocean steamer up the Persian Gulf to Bassorah, and there trans-shipped to the river boats for Bagdad. At the time war started rails had been laid to Samara, about fifty miles north of Bagdad on the Tigris. Material on hand may have since made it possible to extend the line twenty miles farther up the river to Tekrit, but hardly beyond that point.

This would leave about 350 miles of construction remaining to complete the line to Mosul, on the site of old Nineveh, at which point the survey leaves the Tigris and runs almost due west to the Euphrates and Aleppo. If rail communication had been open to Constantinople and Europe, it is conceivable that construction could have been pushed from the western end rapidly enough to have brought railhead to Mosul by this time, from where materials could have been rafted down the Tigris so that work could have been rushed simultaneously at a dozen points where the survey parallels the river. But with Constantinople cut off from Germany up to last Fall, and with the probability that the tunnels in the Taurus mountains are still far from being completed, it seems certain that the shortage of materials must have been felt almost as badly in the West as in the East.

For here, also, ocean transport had been largely depended upon for heavy supplies, and these ceased abruptly with the closing of the Mediterranean to the ships of the Central Powers. So such construction as went on up to the first of this year must have utilized such material as was on hand at the outbreak of the war. At that time rails were laid from Aleppo to the Euphrates, the bridge across this river was practically complete, and a considerable mileage had been constructed across Mesopotamia. The country to be traversed by the railway between the Euphrates and the Tigris is somewhat broken, and the engineering will be similar to that in the non-mountainous portions of Montana and Wyoming, with considerable cutting and filling and a good many short bridges and culverts. This character of construction will predominate in the first hundred miles south of Mosul, after which the survey runs over a slightly undulating plain along the Tigris, where some protective work against floods was expected to be necessary.

Unless there were far larger accumulations of material on hand at Aleppo than there is any knowledge of on the outside, it is hard to understand how the western railhead at this time can be very much over half way from the Euphrates to the Tigris, say about Ras el Ain. And even if railway materials were being rushed through to Constantinople and across the Bosphorus immediately the way was cleared through the Balkans in November, the uncompleted tunnels in the Taurus would still have made it practically impossible to keep anything like an adequate supply moving on to railhead in Mesopotamia. The only thing that might lead one to believe that the Bagdad Railway had been pushed any distance beyond Ras el Ain is the rather remarkable number of troops the Turks were able to throw against the British at Ctesiphon, and the still more surprising numbers with which they have invested Gen. Townsend's force at Kut el Amara and contested the advance of Gen. Aylmer's relief expedition up the Tigris. If, through having had great reserves of structural material and by hard driving of the very poor laborers whom they have had to put up with, the Germans could have completed the line to Mosul, it is quite conceivable that the unexpected Turkish forces entrained to this point and were then rafted down the swift-flowing Tigris to Samara or Bagdad.

The section of the Bagdad Railway from Konia, in Asia Minor, to and through the Taurus and Amanus mountains and on to Aleppo has the eyes of the world upon it at this time from the fact that it is the most important link in the line of communications of the Turko-German army which has been concentrated in northern Syria with the supposed design of invading Egypt and cutting the Suez Canal. Whether anything like a serious threat can be made against Egypt, indeed, depends almost entirely upon whether or not the series of connecting railways extending from the Bosphorus through Asia Minor, Syria, and Palestine to the Sinai Peninsula can be made an adequate line of communication for an army of something like half a million men. Palestine and Syria are hardly able to feed their civilian population in ordinary times, much less so at times like the present, when the production of foodstuffs has been brought to an unprecedentedly low level by the four years of nearly incessant wars that have held Turkey in their grip. This same circumstance has also cut down the food production of Asia Minor, so that an army operating against Egypt must be very largely fed, and entirely munitioned, from Europe. With this fact in mind, the importance of the railway communications at once becomes evident.

Supplies for an army operating against Egypt must come through Asia Minor to Aleppo by the Bagdad Railway—or such of it as is complete—then switch to the French-built line, which would carry them *via* Rayak and over the Anti-Lebanon Mountains to Damascus, and then switch to the German-built Hedjaz Railway, over which they would move to the rim of the Sinai Desert and be trans-shipped to the light railways serving the rear of the army. It is to the "mixed" nature of this line of communications, and the fact that there is still a considerable break in it, that the best informed strategists believe that a sufficiently large army seriously to threaten the Suez Canal cannot be thrown over the Egyptian frontier.

In 1912 the writer met Meissner Pasha, the able German engineer who had built the Hedjaz Railway from Damascus to Medina and who was then getting preliminary work on the Bagdad Railway under way—and, among a number of other questions, asked him if he shared the belief attributed to the German Military Staff that a strong Turko-German force could be thrown across the Sinai Desert to the Suez Canal and perhaps to Cairo. Herr Meissner at that time held the opinion that an absolute *sine qua non* to the success of such a venture would be a double track railway all the way from the Bosphorus to Sinai. With no less facilities, he professed to believe, could the huge army necessary for such a task be adequately served. Although it has been reported that the Hedjaz Railway has been double-tracked south from Damascus to some point near the Sinai Desert, it is needless to say that this condition precedent has been far from realized. Indeed, on account of the still considerable break in the Taurus range, there is not yet—nor is there likely to be before next summer or fall—a through single track railway from the Bosphorus to Sinai. The fact that all ship-

* From the *Railway Age Gazette*.

ments to Syria must be packed or trucked over a 7,500-foot pass, which is blocked from October to April with snow, makes it hard to see how anything like even adequate rolling stock and locomotives can have been assembled beyond the wall of the Taurus.

Although the construction work in the Taurus Mountains has lagged far behind that at any other point on the western portion of the Bagdad Railway—probably on account of the great amount of heavy cutting and filling in addition to the tunnels—the longest bore on the line is the Baghtche Tunnel, 75 miles east of Adana and 60 miles northwest of Aleppo in the Amanus Mountains. This tunnel, we know from the report of the enterprising American Consul General of Constantinople, together with the other rock work in the Amanus Mountains, was finished some time last summer.

"With the completion of this tunnel," reads the report, which bears the date of September 3d, 1915, "one of the most serious difficulties connected with the construction of the Bagdad Railway has been overcome, and the work of connecting up many of the isolated stretches of track may be expected to be completed with reasonable rapidity. In spite of the delays caused by war, this most important undertaking in railroad construction in Turkey has passed the problematical stage and is now certain to become an accomplished fact in the near future."

The *Osmanischer Lloyd* gives the following technical description of this recently completed work in the Amanus Mountains:

"Leaving Mamoure, last station on the Bagdad Railway on the Cilician plain, the line begins, at the foot of the Amanus Mountains, to ascend, at an elevation of 394 feet, the slopes of these mountains, which are intercepted by ravines crossed by eight steel bridges and seven small tunnels, the latter having a total length of 6,355 feet. Thus it arrives at Baghtche station, situated at an altitude of 1,754 feet, near the entrance of the great tunnel which bears its name. Before reaching the mouth of the tunnel the line runs through two other tunnels, having a length of 236 and 394 feet, respectively, and over a small bridge.

"The great tunnel has a length of 16,028 feet. For about 8,000 feet it ascends to 246 feet above the level of the entrance, and then begins to descend and emerges at the other end 197 feet above the level of the entrance. Between this point and Islahie station, which is still building, there are four more tunnels having a combined length of 3,500 feet. The total length of the tunnels which it has been necessary to construct in crossing this great range of mountains is therfore a little more than 26,250 feet.

"The great tunnel with its length of more than three miles, is the longest in Turkey. It is only excelled in length by the great tunnels in the Alps and elsewhere. Still, the technical difficulties which had to be overcome in piercing through have been just as great as those encountered in the Alps. In fact, for several hundred yards, the engineers encountered a rock of practically pure quartz, which was so hard that it was necessary to have recourse to boring machines of special make.

Upon the business future of the Bagdad or any other of the Turkish railways it is idle to speculate at this time. This, like the political future of the region which these lines serve, hinges upon the arbitrament of battle, and into whose control they will be given will not be known until the peace treaties are signed.

Sunlight a Necessity for the Maintenance of Health*

By J. W. Kime, M.D.

THERE are few lessons so difficult to learn as the lesson of sunlight. The chapter on fresh air is beginning to be understood—only beginning, however, for thousands of windows still are tightly closed both day and night which should be widely opened for the admission of the fresh pure air from without. But that light, sunlight, is of the greatest value in the maintenance of health, and even of life, is comprehended by but few, indeed by almost none at all. Even physicians do not know, or, knowing, fail to heed the necessity for the admission of sunlight to their homes.

In consequence we find in every city and in every rural district splendid homes which are swamped in trees —swamped to such an extent that even the grass refuses to grow; the windows are small and few in number, and even upon these, the shades are pulled far down to exclude the light. These homes are dark and often are damp—the very conditions most favorable to bacterial growth. In homes like these ill health must be the rule.

In the plant world light is essential for health and growth. If grown within the house, the shoots are weak and pale and spindling, while just without, where the sunshine falls, the same plants are strong and rugged and clothed in green.

In dark places, in caves and cellars where but few straggling rays of light may enter, plant life is devoid of health and strength and color. The energy imparted by sunlight is wholly lacking; the rich green chlorophyl which only the sunlight paints in grass and leaf and flower is not imparted in caves and gloomy places where sunlight never falls.

The familiar and homely potato proclaims an eloquent lesson of the beneficent powers of sunlight. We store this vegetable in places that are dark and close; a dingy window in the basement wall admits a fraction of light. Along toward springtime the "eyes" begin to swell and soon long, white, fragile sprouts emerge and creep long distances upon the dark cold floor. These "sprouts" are identical with the tough green stalks in the open garden upon whose rootlets these useful tubers grow.

In plant life sunlight measures the distance between life and death.

The human type confined indoors is pale and weak and bloodless. If blood there be it is but tinged with red; the deep red colors which only the sunlight paints are reserved for those who live outdoors.

It therefore comes about in the course of time, and of human events, that every fourth generation we must go back to the rural dwellers for a new influx into urban life. Indeed, were it not for this steady stream continuously flowing from rural to urban districts, our city life would soon lose much of its virile power.

City life is life within doors—in shop and factory, in office and counting room, in homes, too often, from which sunlight is removed; it is life in which the blood runs pale. It is close akin to the life which creeps and crawls on the dark damp floor beneath the house.

There once was a race of human dwellers that lived in caves. They burrowed beneath the ground, they sealed great cliffs and dug into their walls. From out their homes the light of day was wholly shut—and of the cliff dwellers only these caverns now remain.

The dwellers in cities, and too often those in the country, approach in a measure, in their habitations, the darkened homes of these forgotten peoples. Their homes are dark, the sunlight is excluded, the houses are swamped in trees. The conditions are those too nearly related to life within the cave.

Light is an energy of wondrous power. Great trees bend and grow toward it. Light paints the color of every flower and tinges the cheek with the glow of health. Without light, the world would be dead and the firmament be blotted out. In darkness, it is not possible for man to live. Reason fails, the health breaks, and death soon comes.

De Laroquette has observed that "the human body, like the plant, draws from the sun an important part of the energy necessary for the maintenance of life." In other words, the food we eat and the air we breathe do not alone supply all that is necessary for our existence. The radiant energy of the sun is equally necessary to life. We are constantly receiving and absorbing into our bodies light waves either from the direct rays of the sun or from the diffused light about us. These light rays perform an important function in maintaining the body health. Indeed, the cell life of the animal tissues can no more be continued in the dark than can the cell life of the plant when light is excluded from it. And yet the physiology of light has scarce been touched upon.

Sunlight, either direct or diffused, when falling upon our bodies is in part absorbed and in part is reflected from their surfaces. The darker the skin the more absorption takes place. In the African, practically 100 per cent of the sun's rays falling upon his body is absorbed, while in the case of the blond a large percentage is reflected. The amount of light energy which reaches the clothed body is not great as practically all the rays are absorbed by the clothing worn. Hence merely sitting or walking about in the sunshine falls far short of what is meant when we speak of "light treatment" or "heliotherapy."

The sunlight absorbed by the body represents a tremendous energy which becomes a part of the vital assets of the individual. Much of this light energy is taken up by the blood and is carried by it to every organ within the body. Many years of experience by numerous investigators have shown that this energy is not only a real power for good in the maintenance of health, but is applicable to the treatment of a wide range of diseases. Indeed, it was well known to physicians of the earlier centuries that sunlight was one of the most efficient remedies at their command. It was in general use as a therapeutic agent in that day and solaria were built into the homes of many of the wealthy people. Among some primitive peoples, as in sections of South America, sunlight is still used in much the same way it was centuries ago.

But sunlight as a remedial agent was for hundreds of years almost wholly abandoned by the medical profession and it has been only during the last decade that attention has again been directed to it. Sufficient data are now at hand to enable us to make a partial list of the affections to which sunlight may profitably be applied.

The most noticeable results perhaps have been obtained in the treatment of rachitic children and of children suffering from various forms of bone tuberculosis. Rollier of Switzerland, most notably, has obtained marvelous results in this class of patients. He exposes the entire body surface of these children to the sunlight for several hours each day. Almost without exception they at once begin to take on weight and to gain in strength and soon are well on their way to complete recovery.

In anemia very similar results are obtained. Many of these patients have been closely housed, often in homes that are dark, their nutrition is bad, they are in need of just such an invigorating tonic as sunlight proves to be. Their blood is lacking in hemoglobin and this the light produces just as in the plant cell the sunlight brings the bright green chlorophyl.

For like reasons sunlight proves the remedy *par excellence* in diseases of debilitating nature, in tuberculosis and other wasting diseases, in neurasthenia, and in convalescence from disease. Such patients properly exposed to the direct rays of the sun usually respond most favorably to the treatment.

In surgical tuberculosis, and especially after operative procedures to relieve the same, and where healing is slow or refuses to take place, sunbaths offer the best prospect for successful treatment. Wounds and injuries of all kinds heal promptly under the influence of direct sunlight. Solaria are now established in many places near the battle fronts in Europe to give to the wounded soldiers the benefit of this rediscovery of a once forgotten successful method of treatment. It not infrequently happens that where the X-ray has long been tried without success a change to sunlight is quickly followed by relief.

In skin affections sunlight promises brilliant results. As many of these diseases are of bacterial origin, the explanation is not far to seek. Sunlight is the most efficient bactericide known; the light kills the bacteria and the skin heals by natural processes. In lupus, eczema, psoriasis, and other skin lesions of bacterial origin, results are both prompt and gratifying.

In cervical adenitis, and upon surgical wounds made for the relief of cervical adenitis, the light exercises an influence of great value. Particularly is this true when a strong concentration of light by means of lenses is used upon the neck, followed by a general sunbath in which the entire surface of the body is exposed to the direct rays of the sun for an hour or more each day.

Heliotherapy is the treatment of disease by means of sunlight falling directly upon the nude body of the patient, and by the use of sunlight concentrated by means of convex lenses or by concave reflectors and directed upon certain local areas of the body which may be in need of treatment. In cervical adenitis, for example, the strongly concentrated light is played upon the glands of the neck for half an hour and then a general sunbath is given afterward.

Sitting or walking in the sunshine with the body fully clad may be of a little value, but it is not heliotherapy. In the treatment of disease by sunlight not even the thinnest clothing is permitted to intervene, as the clothing absorbs the sun's rays and the full effect of the light is not obtained. Whenever possible the entire body is exposed to the sunlight, the head only being protected.

The patient must very gradually become accustomed to the sunlight, otherwise disagreeable burns may be produced and blistering may occur. The usual method in initiating the patient to treatment is by the exposure of the feet and legs to the light for ten or fifteen minutes on the first day; on the second day the feet, legs, and thighs are exposed for fifteen minutes; on the third day the lower portion of the body is added, and on the following day the entire body, with the exception of the head, is exposed for the same length of time. The daily treatments are now gradually increased in length of time until an hour or more is passed with the full body exposed to the light. In winter the patient may thus lie in the sunshine for a number of hours each day.

No matter what the form of malady for which treatment is given, the exposure of the body is total; in this manner only may all the blood circulating on the surface of the body be flooded with the sunlight.

The revival of the "sun cure," added as it now is to the discoveries made during the past quarter of a century in the field of bacteriology, means much toward the relief of many diseases whose causes are of bacterial origin.

* *The Medical Record.*

A Novel Evaporator

In a recently patented device a circular horizontal plate is rotated about a vertical shaft above a cylindrical chamber through which a suitable heating medium is passed. The liquid to be evaporated is fed onto the center of the plate and is guided toward the periphery by stationary scrapers.

A course in landscape gardening.

A forester camp at Lake Wanakena.

Teaching Scientific Forestry

Valuable Work Done By a State Institution

By Dr. Hugh S. Baker

When the word "forestry" is used, most people think of the work of the Government Forest Service in the West, and its broad efforts in building up one hundred and sixty-three national forests, containing one hundred and eighty-six million acres of land, upon which timber is being raised for the benefit of future generations. The thoroughness and efficiency of this splendid body of men in planting trees and protecting the forests against fire, and in assisting settlers to obtain homesteads within the boundary of the national forests, is an object lesson in the management of natural resources.

Nevertheless, natural resources in general, and forestry in particular, are not entirely neglected in the East. One of our leading educational institutions, the New York State College of Forestry at Syracuse, is now endeavoring to solve the land problem, and to supply a scheme for the management of these natural resources within the Empire State.

The college, established by the Legislature in 1911, does not only teach at Syracuse, but carries its gospel of better forestry and love of the woods, the proper utilization of forest products throughout the State. A four and five-year professional course is given at Syracuse, and a one-year ranger course is given upon the college forest of 1,800 acres at Wanakena.

A State forest camp is maintained for four weeks of the summer in the Adirondacks, and in addition over two hundred popular lectures, illustrated with lantern slides, are given each season before clubs and associations throughout the State.

In the instruction of technical foresters at Syracuse, great stress is laid upon field work, and the training of the hand, for in addition to regular laboratory exercise with note-book and microscope, the boys are compelled to use the axe and mattock from time to time.

During the Easter vacation a number of students are accustomed to work in the State forest experiment station, about a mile south of Syracuse, upon which the college is growing over a million and a half of little trees for experimental purposes.

In fact, much of the labor during the rush season is done by the students themselves. They make the seed beds and plant them, pack the trees for shipment and set the seedlings out in transplant rows so they may grow there a year or two before being sent out for field planting.

The general policy of the college is that men shall not only be thoretically trained, but receive a maximum of practical experience in all branches as well.

In addition to the regular course of training for technical foresters given at Syracuse, the college has made a noteworthy beginning in supplying men to occupy subordinate positions in the management of forest lands. For some years there was a gap between the technically trained forester and the lumber jack. There was no one to whom the consulting forester could intrust the carrying out of his plans, and it is this type of man that the New York State Ranger School at Wanakena is attempting to supply. The Ranger School gives an unusual, thorough and practical training of one year, with the idea of turning out men well fitted for such positions as rangers, guards, tree-planting experts and managers of forest estates.

Spreading out pine cones for seed.

Young men who have already had some experience in lumbering operations, or who are well trained in woodcraft, will find this course of material help to them in preparing for more expert service. The course is not intended to be an education in forestry, and the man who completes it will be fitted for a subordinate position only.

A practical man is turned out and not a professional forester, because the latter type of man requires at least four, and preferably five, years for his proper education. In the work at the Ranger School, as well as at Syracuse, great importance is attached to the benefit obtained from manual labor.

Trees are felled, timber scaled, telephone lines are strung and fire trails cut. This labor constitutes an important part of the regular instruction, and no remuneration is given for it. On account of the demands of the course there is practically no opportunity for earning money to pay expenses while at the Ranger School, for it is felt that students should be able and willing to save sufficient funds to meet their expenses before beginning such a short course.

In addition to the practical work enumerated above, thorough courses in surveying, map making, timber estimating, etc., are given, and in every case class-room work and the actual practice go hand in hand.

The logging and milling operations of the Emporium Lumber Company are situated on the east side of Cranberry Lake, within a short distance of the Ranger School, and the holdings of the Higbie Lumber Company and the Newton Falls Paper Company are also a short distance away. These operations, carried on under skillful management, give the youthful forest ranger useful opportunity for the study of modern lumbering methods and close utilization. The New York State College of Forestry is striving through research and co-operation with lumbermen and all users of forest products to make the best use of the forests now standing.

In addition to the indirect influence of the forests—in controlling runoff, moderating climatic extremes, etc.—and the structural materials which it supplies, the forest yields large quantities of materials for the so-called minor industries. For instance, over 58,000,000 board feet of lumber are annually consumed in the Empire State for musical instruments, of which amount piano manufacturers consume the major portion.

The Spruce of the Adirondacks is especially valuable in the manufacture of sounding boards of these musical instruments, on account of its resonant qualities. Over nine million board feet of spruce are consumed in supplying this part of the piano.

The manufacture of veneers is also an industry of increasing importance in this State. Formerly they

Thinning a hard-wood sprout.

Students on a trip through the woods.

Learning to use an axe.

were made of such valuable woods as mahogany, walnut, rosewood, cherry, satinwood, etc., but with the growing scarcity of these expensive woods, the furniture manufacturer is now resorting to placing thin sheets of veneer upon the more common woods. In addition, other species of less value are being transformed into veneer, and red gum, yellow pine, hard maple, yellow poplar and cottonwood furnish the market with a considerable portion of the veneers used. The old prejudice against veneered furniture is passing because it is often stronger and more durable than furniture made entirely of the valuable species.

In its endeavor to make the practice of forestry as widespread as possible, the college is offering assistance to owners of small tracts of forest land. Where the woodlot is more than 300 acres, and where there is assurance that the plans made by the college will be carried out, assistance is given gratis; but where there is less than this amount the owner is required to pay traveling expenses and sustenance of the forest expert. Very often the owners of timber land in a town or community may lump their holdings, and thus avail themselves of the free offer which is made by the college.

Reforestation is also advocated by this institution.

In spite of the compaign of popular education along forestry lines, which has been carried on for nearly forty years, the average citizen of to-day has little clear knowledge about the meaning and scope of forestry. Forestry really means the raising of repeated crops of timber from non-agricultural soils. It is not agriculture, nor a part of it, because agriculture is concerned only with tillable fields, while the forester's aim is to raise repeated crops from the soils which the agriculturist cannot use. Neither is forestry lumbering, but conservative lumbering—the harvesting of the forest crops—an important phase of forestry activity. The city forestry, of which we hear so much at the present time, is in reality only a first cousin to forestry proper because in the cities shade trees for purposes of beauty are the prime consideration rather than timber for structural purposes.

Museums as Aids to Forestry*

By Harlan I. Smith, Museum of the Geological Survey, Ottawa

In gaining due recognition and support from the great mass of the people, museums may be great aids to forestry. Even the further application of museum methods in forestry may be of valuable service. The extent of the possibilities in these lines of recruiting aid by means of museum methods of publicity, recreation, instruction and research can hardly be forecast. Such museums or methods, however, must be properly administered to be effective. The methods used, for instance, in the large and costly Botanical Museum in New York would be of little or no avail to forestry. That museum may be of use to scientists, but is not of great human interest to me, and, therefore, I judge, not to the average citizen, lumberman or forester.

Vast expenditure of time and money is not necessarily needed to secure valuable aid by these means. Museum cases, if such are really required, may be made at a cost of less than four dollars per foot front, as I have pointed out in the Ottawa *Field Naturalist* of May-July, 1915, and the Scientific American Supplement of May 29th, 1915. A large collection of specimens, maps, photographs and labels is not needed to inoculate whole regions with the germs of the ideas of the practicability and economic importance, to say nothing of aesthetic values and the love of forestry. A small exhibit may teach the general and valuable principles of forestry, perhaps even better than a complete exhibit of all kinds of trees, such as is shown in the American Museum of Natural History in New York. Such a complete exhibit might confuse or burden. The persons to be influenced to give aid to forestry might be lost in the woods, as it were.

In the Rocky Mountains Park Museum at Banff, Alberta, a beginning of a tree exhibit has been made. There are eleven species of trees in the park. Five grow in the valley, but the other six are found only on the higher land. A complete collection of the trunks and leaves of the trees growing in the valley was made in two half days as a by-product of other work, and without any expense except for time in cutting the trunks to lengths for exhibition. At the same time two photographs were made of each of these five kinds of trees; one of a grove or group of each kind of tree from a distance, and one of the details of the trunk, bark, leaves and such flowers or fruits as were then in season. Later photographs are to be made of the parts of the trees not yet taken, and of uses and abuses of each tree and its products.

Training in wood-craft. Putting up a forest telephone line.

Tentative labels had previously been prepared at my request by the late Mr. Abraham Knechtel, chief forester of the parks branch of the Department of the Interior. These refer particularly to the park, and consequently are to be revised so as to serve as labels for the same trees in any other museums that may accept the labels. Supplementary labels describing the peculiarities of these trees as to the park are also in preparation.

These labels were printed in the "Handbook of the Rocky Mountains Park Museum," and from the same type the labels were printed for labeling the specimens in the museum. The museum labels were printed on cards of a yellow color to harmonize with the furniture of the museum and with a brown ink for the same purpose. They were framed and securely screwed to the trunks of the specimens so that they cannot easily be displaced. The glass covering them, which can be cleaned readily by any janitor, protects the label from dirt or defacement. When these labels are revised to include instruction and explanation of the most important of the forestry abuses and needs, and when specimens of uses of the lumber and other tree products, such as wood alcohol, charcoal and turpentine, are added with full labels, this exhibit will be the beginning of a suggestion for a museum aid to forestry.

An example of the facts that should go in a label is that the obnoxious pitch of the balsam is so largely in the bark that the wood, formerly not used at all for paper pulp, is exceptionally valuable for this purpose.

The qualities of a great number of woods may be shown by the exhibition of the volumes of "American Woods," published by Hough, illustrtaed by cross, radial and longitudinal sections of actual trees. But certainly to accomplish the best results expert foresters who know the scientific facts must co-operate with those who understand people well enough to translate forestry facts into terms that not only can be understood by those whom forestry seeks to convert to its aid, but into terms that will also attract those people to read the labels and study the specimens.

The same labels may serve as outlines for lectures, each label being illustrated by lantern slides made from the photographic negatives previously mentioned. It is part of the work of all progressive museums to give popular lecture interpretations of science as well as scientific lectures and recreation based on instruction. Then, too, the museum may send out both traveling exhibits of forestry and lecture outlines made up of the labels, together with loan sets of lantern slides. The great value of a museum is to supply practical facts and stimulate public interest.

* Presented at seventh annual meeting of the Commission of Conservation, Ottawa, Canada, Tuesday, January 18th, 1916.

Physical and Mechanical Factors in Corrosion*

How the Mechanical Heterogeneity of Metals Affects the Process

By Cecil H. Desch, D. Sc., Ph.D.

It is generally recognized that the corrosion of a metal or alloy is intimately connected with the formation of local electrolytic couples at the surface in contact with the solution or atmosphere. The process of corrosion is always initially one of chemical solution, the dependence of which on electrolytic conditions is established. A highly purified specimen of zinc is almost inactive toward acids, while commercial zinc, containing lead, is rapidly attacked, the action of the acid beginning in the immediate neighborhood of the lead particles. This is one of a large class of similar facts, the bearing of which on the question of corrosion is often overlooked. The object of the present paper is to show how the mechanical heterogeneity of metals and alloys affects the nature and velocity of the process of corrosion.

Laboratory tests of corrodibility are commonly made for the purpose of determining which of several materials will offer the greatest resistance to corrosion when exposed under certain specified condition. As it is impracticable to reproduce these conditions exactly on account of the long duration of the tests, rapid tests, involving the use on the one hand of active chemical corroding agents, or on the other of an applied electro-motive force, are commonly adopted. Such tests are usually of an unsatisfactory character. A number of metals or alloys, arranged in order of their resistance to acid solutions, will present a very different order when exposed to technical conditions, such as contact with town air or sea water.

Moreover, tests which involve the determination of the weight of material removed by the corroding agent, usually including that which is removed by brushing or scraping after corrosion, confound a number of successive changes in such a way that their separate influences cannot be disentangled. For example, experiments which determine the relative loss of weight of specimens immersed in an acid or salt solution for equal periods of time fail to distinguish between (*a*) the material actually dissolved and remaining in solution, (*b*) the loose, flocculent precipitate of basic salts which is produced in salt solutions, (*c*) the adherent film of basic salts which in some cases has the properties and effect of a tough, protective varnish, (*d*) the metallic layers, such as the spongy layer of copper formed in the "dezincification" of brass, and (*e*) crystals mechanically dislodged from the face of the specimen by solution of the material surrounding them. All these five products are removed when the specimen is brushed or scraped before reweighing, but their relative quantity is not determined, although the power of a metal or alloy to resist corrosion depends in no small measure on the ratio between these quantities. From an examination of the surface after an experiment of this kind the corrosion is described as "general corrosion" or as "pitting," the latter referring to localized attack, the solution of the metal being either entirely limited to or greatly intensified in definite areas. Microscopical examination, however, often shows that what is apparently general corrosion is really pitting on a minute scale. An annealed α brass exhibits true general corrosion, the surface being uniformly attacked, except that neighboring crystal grains of different orientation may show slight differences of level. On the other hand, a light aluminium alloy corrodes by minute pitting, the pits bearing a definite relation to the arrangement of the micrographic constituents.

The heterogeneity which gives rise to the formation of local couples may be of two kinds, chemical or physical. A pure metal is of necessity chemically homogeneous in the sense that it is made up of only one kind of atoms, but it may be physically heterogeneous. A metal which has been "cold-worked," or deformed at a temperature below that at which complete recrystallization takes place, contains, as shown by Dr. Beilby, films of amorphous material between the separate crystal grains. The amorphous metal is more electro-positive than the crystalline, as is shown by measuring the difference of potential between two specimens of the same metal in the cold-worked and annealed state respectively (W. Spring, *Bull. Acad. Roy. Belg.*, 1903, 1066), consequently cold-rolled metals almost always corrode in such a way that greater chemical action takes place along certain lines than along others, such lines following the direction of the rolling. This effect is not to be confused with the striation observed on the surface of rolled plates due to the inclusion of impurities. Rolled sheet-iron will corrode in parallel lines even in the absence of cold-working, on account of the presence of particles of scale which are embedded in the surface during rolling and produce a heterogeneous structure. Cold-worked metals become striated during corrosion, however, even when the outer skin has been completely removed before the test was made.

There are thus two reasons for the greater corrodibility of cold-worked than of annealed metals: the more electro-positive character of the former and their greater heterogeneity. Against this must be set the fact that some metals are commonly porous in the cast or annealed state, and that the closing of the surface pores by cold-rolling may increase the resistance to corrosion, in some cases more than compensating in this way for the electro-chemical difference. This applies mainly to atmospheric corrosion; in contact with liquids the electro-chemical differences assert themselves more strongly.

It is possible that even annealed metals of high purity may be minutely heterogeneous. Several observers (H. Heller, *Zeit. Phys. Chem.*, 1915, lxxxix, 761; E. Cohen and W. D. Heldermann, *Ibid.*, 733; H. J. M. Creighton, *Journ. Am. Chem. Soc.*, 1915, xxxvii., 2064) have recently described the disintegration of lead in contact with an electrolyte. A specimen of sheet lead, immersed in a slightly acid solution of lead nitrate or acetate, gradually becomes loosened in texture, and is ultimately converted into a spongy mass of crystals, the metal being obviously dissolved and re-deposited. The writer has repeated this experiment several times, and finds that it is indifferent whether commercial sheet lead or the purest assay foil be taken. Cold-working is here excluded, as lead anneals itself spontaneously at the ordinary temperature. Whether lead be, as Cohen assumes, a mixture of stable and metastable allotropic modifications, of which the latter would tend to dissolve and recrystallize as the former, remains to be proved.

Local cold-working greatly accelerates corrosion. The severely cold-worked condition which prevails around a punched hole in a boiler-plate is always the spot at which corrosion first appears if opportunity offers. The contact of cold-worked and annealed metal in an engineering structure is for this reason undesirable.

Besides the physical condition of the metal, that of the product of corrosion has to be taken into account. When iron rusts the product is porous and bulky. It affords a ready passage to the corroding liquids or vapors, while at the same time, being strongly electro-negative to iron, the ferric oxide furnishes innumerable local couples which accelerate corrosion. On the other hand, the layer of oxide formed on aluminium under normal conditions is extremely tough and coherent, and prevents further corrosion when a certain small thickness has been reached. Where corrosion is more rapid the coating may be porous. The loose coating of oxide which is formed when aluminium is rubbed with mercury has no coherence. In moist, tropical countries aluminium corrodes more rapidly, and the coating, although apparently continuous, may be minutely porous. Aluminium drinking vessels in hot climates acquire a foul taste, doubtless owing to the absorptive properties of this porous coating of oxide.

With a view to examining changes in the physical condition of the metal and of the corrosion product, as well as the amount of corrosion, the writer has carried out several series of experiments, mainly in collaboration with Mr. S. Whyte, B.Sc., with alloys of copper with zinc and other metals (Desch and Whyte, *Jour. Inst. Metals*, 1913, x., 304; Whyte and Desch, *Ibid.*, 1914, xi., 235; Whyte, *Ibid.*, 1915, xiii., 80; Desch and Hyman, *Ibid.*, 1915, xiv.). Specimens of the size used for microscopical examination are corroded in a salt solution, being made the anode in a cell of 1 or 2 cubic centimeters capacity with a platinum gauze cathode. If necessary the action is hastened by the application of a small external electro-motive force. A temporary containing vessel is built up of plasticine. After a determined time the contents of the cell are washed out into a beaker for analysis, and the surface of the specimen is examined. In this way a separate analysis of the products (*a*) to (*e*) may be made, the adherent deposits being removed by gentle scraping if necessary. Special colorimetric methods of analysis are used to determine the proportions of dissolved metals, amounting in some cases only to a hundredth of a milligramme or less, and in the continuation of the work micro-chemical methods are being used. The specimen is examined microscopically at each stage of the process. A convenient laboratory apparatus has been devised by means of which successive experiments may be made rapidly under exactly similar conditions (Desch, *Journ. Soc. Chem. Ind.*, 1915, xxxiv., 258; Desch and Hyman, *loc. cit.*).

When an annealed α brass, which consists of a homogeneous solid solution, is corroded under these conditions, using a 5 per cent solution of sodium chloride and an applied electro-motive force of 2 volts, the surface is attacked, zinc being dissolved much more rapidly than copper, so that a surface layer is obtained, consisting mainly of metallic copper mixed with basic salts. When the latter are removed by washing with very dilute hydrochloric acid, copper is left in very perfect octahedral crystals. It is interesting to observe that this dezincification takes place *per saltum*, there being an abrupt change from copper to unaltered brass, without any intermediate zone in which the proportion of zinc is less than that originally present, but greater than in the superficial layer. This is characteristic of the dezincification of brass, whether occurring naturally in the course of use or brought about artificially as described above. A transverse section shows this clearly. Under a higher magnification, it is seen that the dezincification proceeds along the boundaries between crystal grains, indicating that the bounding surfaces are more strongly electro-positive than the mass of the crystals. Where twinned crystals are present, as in annealed brass, the removal of zinc also proceeds along twinning planes.

The spongy layer of crystalline copper offers a very large surface, and is therefore readily oxidized. This fact accounts for the presence of a bright red layer, consisting mainly of cuprous oxide, on the corroded surface of brass tubes. The oxide layer is of secondary, not primary, origin.

An unannealed cast α brass is not quite homogeneous, but exhibits "coring," each crystal grain becoming richer in zinc from the center to the periphery. Such an alloy, owing to imperfect homogeneity, is rather more rapidly corroded than annealed brass, but the difference is not large.

The homogeneous β brasses, which are in general too brittle for industrial use, are corroded in a similar manner, but more rapidly. The process is almost entirely one of dezincification, very little copper being dissolved, while the residual layer contains sometimes as much as 99.6 per cent of copper. The crystalline structure of the brass beneath this overlying layer is very clearly developed, and in other respects the process advances just as in the α alloys.

Alloys of the Muntz metal class have a duplex structure, being made up of the α and β solid solutions in conjunction. It was observed by Milton and Larke (J. T. Milton and W. J. Larke, *Proc. Inst. Civ. Eng.*, 1903, cliv., 138) that the corrosion of Muntz metal in sea-water proceeds in such a way that a bolt or plate may retain its form and metallic appearance perfectly, although almost devoid of strength. A transverse section shows an outer layer which is copper-red in color, and often an inner core which is yellow, but brittle and weak, while if the corrosion has stopped short of completion there may be a central core of unchanged metal. A similar observation had been made by Arnold (J. O. Arnold, *Engineer*, 1898, lxxxv., 363), whose explanation is confirmed by microscopical examination. The β constituent, being the more electro-positive, is first dezincified and converted into a mass of porous, crystalline copper. The dark β areas are replaced by copper. Only when this change has progressed to some depth does the attack spread to the α crystals, after which the removal of zinc from these proceeds to completion. The spongy copper retains the original form of the crystals, so that a perfect pseudomorph remains, showing the original arrangement under the microscope. This successive replacement of the two constituents by copper was first observed by Arnold (*loc. cit.*), who showed that the strongly electro-positive β was first attacked, and that after its conversion to copper it became electro-negative to α, and so accelerated the corrosion of the latter. When the β has been so far attacked that it has the same composition at the surface as the α, it might seem that a state of equilibrium would be reached, after which the two would be attacked equally, but in fact the great porosity of the partly corroded β causes the attack to be confined to it entirely.

Reversals of electrolytic action of this kind are sometimes very striking. When a mild steel containing manganese is corroded in the small electrolytic apparatus, the ferrite only is at first attacked, leaving the pearlite bright and in relief (Desch and Whyte, *J. W. of Scotland Iron and Steel Institute*, 1914, xxi., 176). The structure at this stage is just the reverse of that produced by etching with acids. Reversal then takes place, and at one point the whole surface is equally darkened, after which the pearlite is more rapidly attacked, and ultimately ferrite is left in relief, as in ordinary etching. The point of reversal coincides with the maximum solu[illegible] of man-

* A contribution to a general discussion on "The Corrosion of Metals," held before the Faraday Society.

ganese, and after it is passed the ratio of manganese to iron going into solution again falls.

The effect of a second constituent in accelerating corrosion is also shown in a light aluminium alloy, containing about 4 per cent of copper. A eutectic of aluminium and $CuAl_2$ is present, but in such small quantity that a eutectic structure is rarely seen, and the compound mostly presents itself in narrow, isolated masses. When electrolytically corroded in salt solution, the compound remains unattacked, and the ground-mass, instead of dissolving uniformly over its entire surface, is pitted locally, the pits being closely related to the masses of $CuAl_2$, either immediately adjoining them or following their outline at a short distance. The influence of local electrolytic couples is here obvious.

In gun-metals it is the α constituent which is first attacked, the eutectoid δ remaining in relief until the corrosion is very deep. In copper-tin α β alloys, the electrochemical difference between α and β is very small.

The protective action of certain metals when added to alloys is next to be considered. As the result of experience in the behavior of alloys in sea-water, the Admiralty introduced the use of 1 per cent of tin in α β alloys of copper and zinc. The resulting "naval brass" is much more resistant to corrosion by sea-water than the simpler alloy. The explanation of this effect is not immediately obvious. The 1 per cent of tin enters into solid solution, and has no effect on the structure beyond slightly increasing the proportion of β, a change in itself conducive to corrosion. The lowering of the electrolytic potential of the brass by the solution of the tin is too small to have any appreciable effect. The experiments cited above have shown that the actual protective effect is in all probability purely mechanical. At first, the presence of tin very slightly accelerates corrosion, but in a neutral or slightly alkaline electrolyte a layer of basic tin salt is rapidly formed and adheres to the surface so firmly as to form an almost impermeable varnish, which protects the metal from further action. The α brasses are similarly protected by the addition of 1 per cent of tin, the alloy 70: 29: 1 being in common use for condenser tubes.

Lead exerts a protective action on an α brass when present in sufficient quantity. It does not enter into solid solution, and each particle, being electro-negative, causes local dezincification in its immediate neighborhood. With 1 per cent of lead, this appears to be the extent of its influence, which is therefore harmful, but a larger proportion of lead gives rise to the formation of a sufficiently tough layer of basic salts. The good quality of condenser tubes containing 2 per cent of lead is thus explained.

A layer of manganese oxide may exert a protective action. Thus light aluminium alloys, one of which contained 2 per cent each of copper and manganese, and the other 3 per cent of copper and 1 per cent of manganese, became coated with a dark adherent layer when kept for 121 days in sea-water, the corrosion being much less than that of pure aluminium (W. Rosenhain and F. C. A. H. Lansbury, Ninth Report to Alloys Research Committee, *Proc. Inst. Mech. Eng.*, 1910, 283).

On the other hand, basic salts which fail to form a closely adherent varnish may greatly accelerate corrosion. This is especially so with copper oxychloride. In a case investigated by the writer, some brass locomotive boiler tubes were found to be very badly pitted, especially at the fire-box end. In each pit was found a small mass of green copper oxychloride, which had served as the electro-negative part of a local couple. The coal used in the locomotive proved to have been repeatedly drenched with sea-water, so that chlorine and hydrogen chloride were formed during its combustion.

The formation of local couples may also be brought about by the adhesion of loose particles of a substance electro-negative to the metal being corroded. It is generally considered that particles of coke often play this part in the corrosion of condenser tubes. This has been disputed in the valuable Second Report to the Corrosion Committee of the Institute of Metals (G. D. Bengough and R. M. Jones, *Jour. Inst. Metals*, 1913, x., 13; for the First Report, see G. D. Bengough, *Ibid.*, 1912, vii., 51), but recent experiments seem to establish it (A. Philip, *Ibid.*, 1914, xii., 133). Such an effect is in accordance with the general behavior of electro-negative particles.

It is believed that the method of study of corrosion outlined in the present paper, by taking into account the mechanical and physical factors involved in the process, makes it possible to investigate, with more precision than is possible in the ordinary methods of testing, the mechanism of the process, and it is for this reason that an account of the preliminary results is laid before the Society.

The Transport of Material in the Form of Dust*

By T. C. Cloud

The removal and transport of very fine material in a works or manufacturing concern are operations which are generally difficult to carry out economically; frequently they can only be performed at considerable personal inconvenience to the work people concerned. It will be sufficient to call attention to a few of the operations to which we are so inured as to look upon them as necessitated. Take, as an instance, the most common case—the cleaning and removal of the dust from the flues of a set of Lancashire boilers. The men enter them with brushes and shovels and laboriously remove the accumulated dust, the work being rendered all the more troublesome from the very fine condition of the material and the extremely cramped space in which the work has to be performed, to say nothing of the heat still retained by the brickwork. When the dust has been deposited in a heap in the boiler house ready for removal, it is troublesome to handle, the slightest breeze sends it all over the place, and as it can only be damped with difficulty, the loading up for final removal adds further to the nuisance.

In some manufactures there is also the production of impalpable powders in large quantity. The following is a mode of dealing with this fine powder. The material may be ground and the particles of requisite fineness removed from the grinding plant by a current of air so regulated in strength that only material of the finest possible size, in fact dust, is removed. This is blown into large chambers, where it is allowed to settle. From these settling chambers it is necessary to remove the accumulated dust at intervals and convey it to another part of the establishment, where it is mixed with other material or otherwise treated.

There is also the case of chemical reactions resulting in the production of impalpable, precipitated substances which, when dried, have to be moved to the department where further operations are carried out. In these and all similar cases the disagreeable nature of the labor involved will be recognized by those engaged in such manufactures.

It will be obvious that, in many of the industries, such materials in fine state of division may not only be disagreeable and troublesome to handle, but may be, and frequently are, of a distinctly poisonous character.

We will take, as an instance, a large smelting works treating argentiferous lead or lead copper ores, perhaps containing small amounts of arsenic and zinc. Such ores would be smelted in furnaces; in addition to the direct furnace products, they will give off very fine dust and also a smoke, which contains fume composed of various chemical compounds derived from the elements in the ores treated and their interaction, or as the result of heat and the chemical action of the furnace gases. The consequence of this is the production of flue deposit, which is collected in long flues built either underground or above ground to suit the local conditions. The cleaning of the flues is exceedingly troublesome, especially if they are built underground, and involves considerable annoyance and discomfort to the men engaged. If the flues are built overhead and are suitably designed, the cleaning out is much facilitated, but the men engaged in drawing the dust off do not altogether escape its irritation and sometimes poisonous action on the system.

In a case where the opportunity was afforded the author of making an entirely new departure in the moving of this class of material, the furnaces were producing a gas highly charged with arsenious oxide. This was, to a large extent, deposited in a complicated system of condensing chambers and flues, followed by filtration through bags in a bag house. The points at which it was necessary to remove the arsenious oxide from the bag house, flues, etc., were numerous, and it was also necessary to deliver all the material to the packing room, where it could be packed in casks for marketing. After considering the existing methods for removal and transport of this material, none of which appeared suitable, experiments were made with a powerful vacuum-producing plant, such as has lately been placed on the market and was originally used for the removal of dust from carpets and household furniture. This class of plant has lately been successfully adapted to the cleaning of boiler flues, and it appeared to the writer that such plant, with certain modifications, might be made suitable for the purpose in view. After some preliminary trials with a small plant, and also with one of double size, an installation was designed and erected of which the following is a description.

The vacuum pump, at normal speed (160 revolutions per minute), has a displacement of 20,000 cubic feet per hour and will produce a vacuum of 18 inches of mercury if all valves to the various branch mains are closed. In the packing house, the pipe main enters a cyclone separator in which the bulk of the arsenious oxide is deposited. Following this is another smaller separator. Finally the air is drawn through a shallow layer of water and then passes to the vacuum pump. The cyclone separator has a small storage capacity and the arsenical soot is automatically removed from this apparatus and discharged into the casks placed below. The smaller separator is furnished with baffle plates and collecting receptacle from which the deposit is only discharged at long intervals when the vacuum is off. The water separator is arranged so that a small continuous supply of water can be passed through it, or it may be charged and discharged intermittently.

The mains about the works are of ordinary gas pipe, which need only be screwed together in the ordinary way. All bends and entering branches are of large radius and, for moving the material upward, all vertical members are avoided and inclined pipes substituted. At numerous points about the works capped branches are arranged, to which, on removal of the cap, suitable flexible hose can be attached; either flexible metallic hose or reinforced rubber hose answers well. A suitable nozzle is fixed at the end of the hose, and on inserting this into the accumulated deposit, the latter is immediately sucked up and conveyed to the separating plant. This plant, having an air pump capacity of 20,000 cubic feet per hour, deals with one and a half to two tons of collected arsenious oxide per hour, and the farthest point from which a branch is situated is about 200 yards from the separator. The pump, in this instance, is electricaly driven, and absorbs at the rate of 12 to 14 horse-power. The ease with which collecting hoppers, condensing chambers, flues, etc., are cleared out is remarkable. The men work entirely from the outside, the nozzle end of the flexible tube being pushed into the material, which disappears in a surprisingly rapid manner, and, of course, without the production of the slightest amount of dust. All the annoyance to the men caused by the handling of this material is removed, and respirators are superfluous.

It is easy to see how such a plant may be adapted for the removal and transport of such materials as are referred to in the first part of this paper, and many others will probably occur. The writer is convinced, after seeing what can be done in the case of a plant in operation, that a similar plant can be made to work successfully over greater distances and on larger quantities, and there appears no reason to doubt that the system can be satisfactorily applied to deal with any quantity of suitably fine material.

* *Journal of the Society of Chemical Industry.*

Signaling at Sea

A method of estimating distances at sea in fog or thick weather, which is partly electrical in character, was described before a recent meeting of the Royal Society, London, by Prof. J. Joly. The system depends for its successful operation upon the different velocities of disturbances in different media. If aerial and submarine signals are simultaneously emitted at a lighthouse station or lightship, the lag of the aerial compared with the submarine sound is about 4.3 seconds to the nautical mile. An approaching ship picking up the signals and measuring the lag to an error even of one second, becomes aware of her distance to less than one-quarter of a mile. Similarly, wireless signals and submarine signals, or wireless and aerial signals, may be used. If the faster moving signals be sent out in groups, the individual signals being spaced to regular intervals, say of one second, and the slower moving signal be always emitted simultaneously with the first signal of a group, the navigator has only to count the faster signals till the slower signal reaches him in order to estimate his distance from the signal station. In this case the signals themselves tell him his distance, and no actual time measurements are required on board ship. It is shown that this system enables the mariner to determine his position completely under all circumstances which may arise. Prof. Joly showed how an extension of this method could be applied to the problem of avoiding collision in fog. It was pointed out that if vessels possess the means of emitting a loud and crisp sound signal which can be sent out simultaneously with a wireless or a submarine signal, the determination of distance rendered possible thereby, along with wireless information as to course and speed, will enable the navigator on each ship to determine with certainty (1) whether there is risk of collision or whether there is no risk, and (2) the point upon his own course and the moment at which collision is threatened.

The solution of the problem is based upon the fact that at each instant the rate of mutual approach is the maximum if the ships are advancing so as to collide. A simple geometrical construction, which, by its character, is unlikely to involve error, enables the mariner to solve the problem immediately the signals are received.—*Shipping Illustrated.*

Great Electro-Magnets—I*

Wonderful Instruments Proposed for the University of Paris

In a recent *Rêvue Générale des Sciences Pures et Appliquées*, Prof. A. Cotton of the Sorbonne presents a *résumé* of the investigation of magnetic fields. This has particular reference to the proposed extension of research in this division by means of funds the nucleus of which has been already placed at the disposal of investigators. The article by Prof. Cotton is a very long one, and for the Scientific American Supplement it has been necessary to select only portions of an admirable story.

The researches that concern themselves with magnetic fields are very varied in their nature, some of the lines of work being with matter at different temperatures, with the action of charged particles, with rotary magnetic polarization, while in other departments are questions of magnetic bi-refraction and molecular symmetry. Such

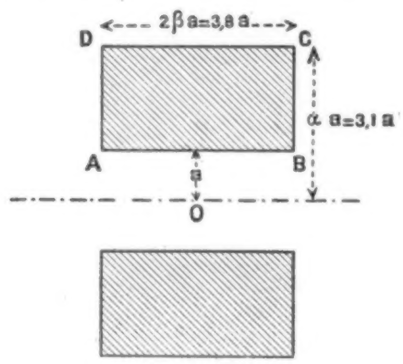


Fig. 1.

investigations have already furnished important results, but they are also full of promise for the future.

One barrier to research is that the magnetic fields are themselves limited. They may be too weak for the desired observations—no fields above 50,000 gauss having yet been measured—and they are limited in extent, the highest fields having a cube of a few millimeters only. Research would undoubtedly be greatly advanced were there available, for example, fields of 100,000 gauss in spaces five or six times larger than those now possible.

In his preamble Prof. Cotton further considers the situation. The new and powerful equipment must be constructed with well-known principles in mind. It would be unfortunate if the technique of obtaining the field were so delicate as to absorb all the attention of the experimenter. Then the field must be uniform and constant. It is further necessary to look at the costs from two points of view. There is the initial cost of the installation and there are the running expenses. Even if the instrument were comparatively inexpensive, should its use entail costly currents for long times, and some of the researches demand hours of continuous running, the frequent repetition of experiments might be out of the question.

Prof. Cotton next takes up the methods of establishing magnetic fields and their relative advantages and disadvantages. They may be established in a number of ways. One can use permanent magnets, solenoids, electro-magnets of the usual form, of the Weiss type or of that of Deslandres-Pérot.

Although permanent magnets cost practically nothing for running expenses they do not permit convenient and quick changes of field, and are out of question for researches of this kind.

A solenoid traversed by a current has a field proportional to the current and it is easy with such an instrument to vary the field at will. On the other hand, there is the resistance that manifests itself in heat. Any consideration of the solenoid must take into account the form of the coil and the manner of winding, items necessary in computing the energy needed for a given field, and besides this there must not be neglected some provision for carrying away the heat.

Whatever the form of the solenoid, so long as the section is a rectangle (Fig. 1), a trapezium (Fig. 2), or an assemblage of rectangles or trapeziums (Figs. 3 and 4), the formula for the energy in watts, W, necessary to produce the field H, is

$$W = \rho \eta a \frac{H^2}{K^2}$$

in which ρ is the resistance in ohms/centimeters, η the reciprocal of space factor or the relation of total volume of the coil to volume occupied by the conductor. The value of this relation is always more than unity and depends upon the space required for insulation and cooling. K is a purely numerical co-efficient which depends upon construction. The greater the value of K, the better the action of the apparatus.

When the coil is cylindrical with uniform winding the coil of maximum efficiency is represented in Fig. 1. For this coil K = 0.179, and diminishes slowly when a different rectangle represents the section. A cylindrical coil gives the highest value of K if the winding instead of being uniform has larger wire as it gets more distant from the axis, but it is difficult to surpass K = 0.20.

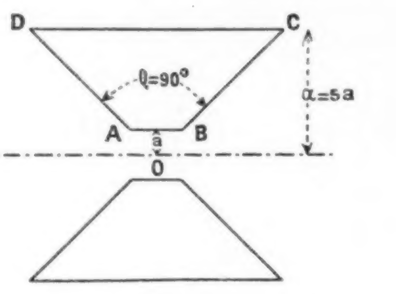


Fig. 2.

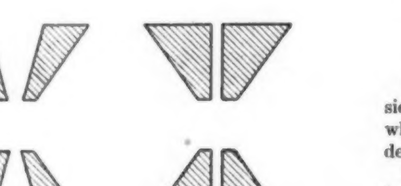


Fig. 4.

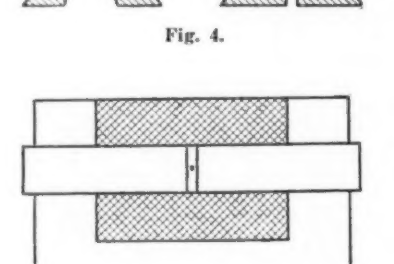


Fig. 5.

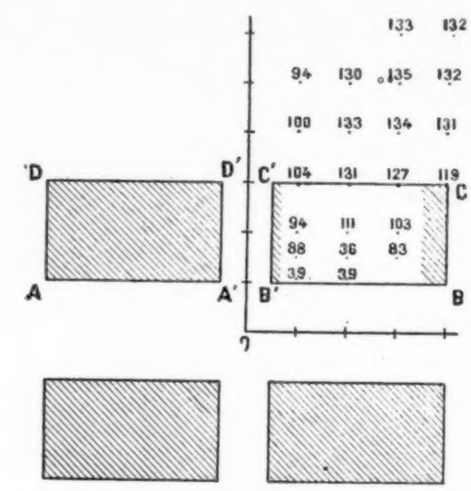


Fig. 3.

Taking other factors Prof. Cotton comes to the conclusion that to produce a field of 100,000 gauss in a solenoid whose central hole is 1 centimeter radius, there will be demanded 800 watts.

The coil whose longitudinal section is a trapezium is an interesting study whether the winding be uniform or not. When the winding is done—as in the Deslandres-Pérot instruments—with a spiral ribbon of metal of uniform thickness but of increasing width, the current density varies inversely to the radius of the turn. The value K here varies quite slowly with the varying profile. The most advantageous form in point of efficiency is that shown in Fig. 2, and is here 0.21. The service is a little better than with the cylindrical coil, but the field is less uniform though somewhat more extended.

Considering coils of two parts separated by an interval as shown in Figs. 3 and 4, the field may easily be computed. In Fig. 3, where the separation of the coils is equal to the radius of the hollow center, the values of K are indicated for several forms of coil. The numbers are K multiplied by 1,000. Below each one is a dot which indicates the place of the corner C for the indicated value of K. For the coil figured this is 0.119.

The second problem here is that of carrying away the heat due to the resistance. In a coil, taking its entire volume, there is produced in a second about 25 large calories per 100 kilowatts of input. If there is no cooling the field cannot exceed a few thousand gauss, and cooling is therefore necessary.

To absorb 100 kilowatts, allowing an elevation in tem-

* Translated and abridged from the *Rêvue Générale des Sciences Pures et Appliquées* by J. Ritchie, Jr., for the Scientific American Supplement.

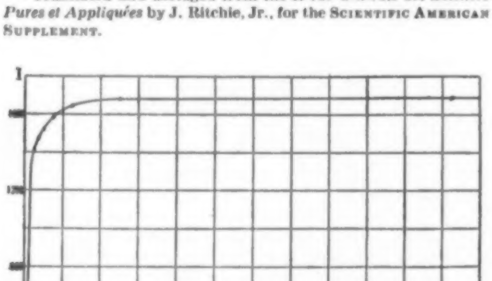


Fig. 6.—Variation of the intensity of magnetization (I) with the field (h).

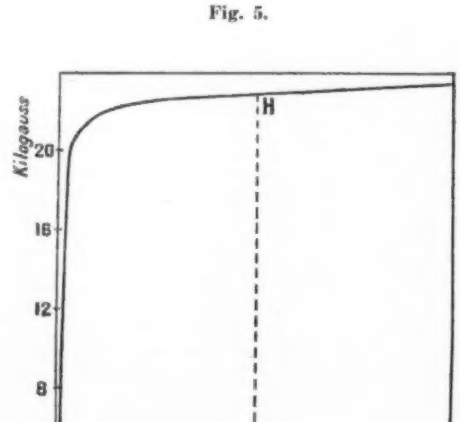


Fig. 8.—Characteristic curves of an electromagnet with iron core. Lower curve, the coil alone; upper curve, coil + core.

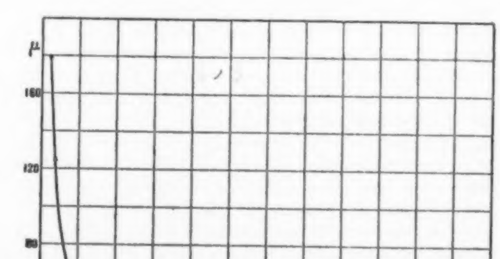


Fig. 7.—Variation of permeability (μ) with the field (h).

perature of 50 deg. Cent. in the water during the process, half a liter a second is sufficient or about 1.8 cubic meters an hour. With water under pressure it is possible to absorb the result of considerable electrical energy in little volume. Weiss and Picard have passed a current of 1,700 amperes into a copper tube whose inner and outer diameters were 2.7 millimeters and 3 millimeters, respectively, through which water flowed at seven atmospheres pressure. Under these conditions the tube absorbed 7.5 kilowatts. Taking account of the space occupied by the insulation and supposing the tube to be square in

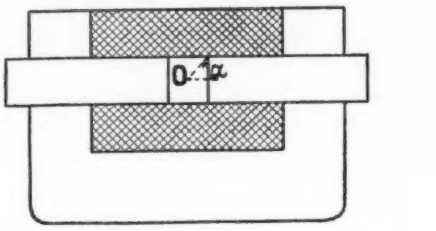


Fig. 9.

section—which permits winding without loss of space—1 cubic centimeter of a coil made with such tube can absorb 2 kilowatts per cubic centimeter of the volume of the coil.

Taking up again the cylindrical solenoid (Fig. 1) for which it is computed that with 800 kilowatts there will be obtained 100,000 gauss in the hollow center of 1 centimeter radius, the volume of this coil is only about 100 centimeters. There can be absorbed then only 200 kilowatts, and the field of the coil can therefore not surpass 50,000 gauss.

For getting around this obvious difficulty there are two suggestions, one of which is to modify the form of the coil into more advantageous shape. A coil whose external radius is eight times that of the hollow interior and with a length of 9, will have a value of $K = 0.15$ with the volume increased eighteen times. Such a device should give approximately,

with 600 kilowatts 65,000 gauss,
with 1,420 kilowatts 100,000 gauss,
with 3,600 kilowatts 159,000 gauss.

A second suggestion is to enlarge the hollow of the coil. The heat problem becomes more and more easy of accomplishment as the coil is made larger, for the energy necessary increases with the radius while the volume throughout which the heat is disengaged grows as the cube of the radius. It will suffice to say here that with a radius of 2 centimeters it will require 1,600 kilowatts for a field of 100,000 gauss. The apparatus is simple, but these are considerable values of electrical power. There is no technical difficulty in getting fields with the solenoid considerably above 100,000 gauss; it is purely the question of money.

The money question is indeed a serious one. There is demanded the use of a power of 2,000 kilowatts. In a city this may not be convenient or even practicable and an experiment lasting several hours would cost thousands of francs. Could it be possible to secure an installation near some factory or could a factory be found that would place such power at the disposal of experimenters in the irregular fashion that the experiments would demand? Such an arrangement would be very unusual in the commercial world. If an independent installation were provided the capital necessary would be of the order of 750,000 francs. Whatever be the solution, therefore, it is to be borne in mind that the solenoid with the plant necessary to produce the power will be extremely costly.

Next there is considered by Prof. Cotton the effect of the employment of low temperatures. The result is that while the resistance of the conductor is diminished and also the amount of heat to be cared for, the cost of energy refrigerating would more than equal the saving. Better types of refrigerating machines must be invented for reliable work and even then the cost is likely to be increased.

This statement of conditions is made on the foundation of French experiments with temperatures down to —25 deg. Cent. Temperatures much lower, those of liquid hydrogen, have been used by Onnes, and here the resistance and the heat have become respectively 1/6 and 9/1000 of their values at ordinary temperatures. The objections are, first, that there is not any convenient liquid which could be circulated in the coil at such temperatures, and one could not dream of putting the whole apparatus into liquefied gas. And besides the results in field remain exceedingly small. Fabry computes that for a coil of the form of Fig. 1 to produce a field of 100,000 gauss there would be needed 100 kilowatts and 1,440 liters of liquid air an hour. Onnes places the liter at ½ kilowatt, so that there would be needed about seven times the energy for refrigeration as for the coil, and hydrogen requires still three times more in energy.

Even were the technique established liquid gas with a solenoid would be very costly and could be utilized only in apparatus of small volume or in small sections of a large coil nearest the axis.

Reference is made to the discovery of the superconductive state by Onnes, which suggested for a while a change in the possibilities of the case. At a critical temperature which lies near the absolute zero the resistance of metals drops with extreme suddenness. In the case of mercury

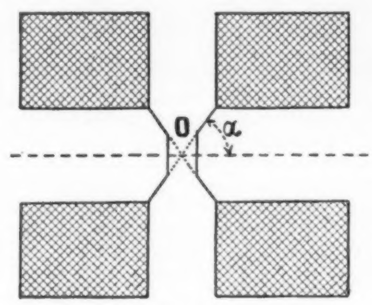


Fig. 11.

in the neighborhood of 2 deg. K. the resistance is less than one billionth of that at ordinary temperatures. Zinc at 3.8 degrees and lead at 6 degrees exhibit this phenomenon. But Onnes discovered other facts presently which were equally unexpected. Superconductors when placed in magnetic fields lose their peculiarity. Superconductive lead if placed in a field of the order of 600 guass shows increased resistance. Then again the intensity of the current in a superconductor cannot be raised above a certain critical value without having the resistance rise suddenly. It is thus evident that the qualities discovered by Onnes do not encourage the employment of extreme cold in connection with intense magnetic fields.

The discussion next takes up the common form of electro-magnet, that furnished with a soft-iron core. Mathematics establish a number of facts for a magnet of the form of Fig. 5, where the soft iron is interrupted in the center and joined at the outer ends by a yoke with a reluctance assumed to be negligible. There are two fields that are superposed, h, the direct field of the coil, and H, the field of the iron core which is uniformly magnetized. The variation of the intensity, I, with h is shown in Fig. 6, being at first very rapid and then hardly sensible as saturation is reached. In Fig. 7 the variations of permeability, μ, with h are shown, these being important during magnetization but always remaining above unity. The iron core, incomparably more permeable than air when the field is weak, remains still somewhat more permeable than air for large values of the field.

Fig. 8 presents characteristic curves for a magnet of this kind, spreading rapidly at first, then more slowly, but separating to some extent always with greater energy applied. The difference between the ordinates of the two curves represents the gain due to the presence of the iron, a gain which is permanent and without expenditure of power.

For a form like Fig. 10, where the cores are separated, the direct field of the coils at the point of utilization, O, is smaller than that of the cores. If the cores be furnished with polar pieces in the form of truncated cones, which serve to concentrate the magnetic flux, the most advantageous forms may be determined by simple formulas. The best half angle for the sides of the polar pieces may be set at about 55 degrees, when there is a common apical point and assuming the magnetization to be uniform throughout.

The value of the field due to the polar pieces is much the most important in ordinary electro-magnets, and its size depends on the magnetic properties of the metal employed for the cores and above all on the shape of the polar pieces. Important advances were made by Weiss, who in his experiments hit upon the alloy ferro-cobalt, which for high values of the field has a magnetization surpassing by about 10 per cent that of iron. It has been used for the centers of the polar pieces, which saturate most quickly, and the gain for the field, already notable, has been achieved without any additional cost for energy.

The field in ordinary forms of electro-magnets due to the direct influence of the coils is much less important than that due to the cores, but it is in relationships in this small matter that the results differ of the various electro-magnets constructed these past few years for laboratories. If the purpose is to increase the numerical value of the measured field, the importance of increasing the coil-influence is evident when the size of the apparatus is increased. One notes therefore in recent constructions the tendency to form more nearly that of Ruhmkorff. Weiss has done this, and Limb with his armored electro-magnets. Various other forms are to be noted, the model of Bouty with cores of 12 centimeters, and coils so arranged that they may be moved and in a fashion surround the poles. The models of du Bois show also an appreciation of the importance of coils near the poles. Weiss has included cooling methods in his recent constructions, and to an extent refrigeration of the coils to make them support more intense currents. The windings themselves are of copper tubes through which water circulates, being delivered cold to the turns nearest the cores. The disposition is effective and accomplishes, among other things, precious in the eyes of precisionists, that the cores do not expand and the air gap remains

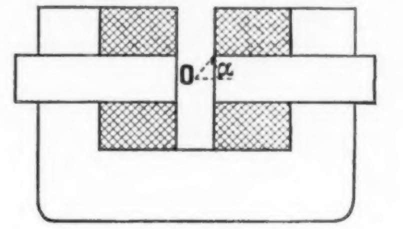


Fig. 10.

constant. Moreover, the temperature remains the same and the resistance of the coil constant, permitting uniformity of current.

(To be continued.)

Aluminium Dust

In the mining industry aluminium dust is chiefly of interest as a precipitant of the precious metals in the cyanide process. It is also used as a reducing agent wherever a powerful metallic reducing agent is required, as, for example, in the production of carbon-free metals, particularly those difficult to reduce, or in the Goldschmidt process of welding (thermit) for producing *in situ* superheated molten iron or steel. Another use is as a "bronze powder" in the preparation of aluminium paint. Perhaps the most important use at the present time is in the manufacture of various explosives. This was first proposed by Escales, of Munich, in 1899, and in 1900 von Dahmen patented the use of aluminium, magnesium, or other light metal mixed with an oxidizing agent. Ammonium nitrate was among the first used of such oxidizing agents. This explosive, called "ammonal," has given good results in mining and as a high explosive in shells. It has the advantage of being insensitive and very stable, as indicated by the fact that in Austria-Hungary shells filled with it were found good after ten years. Recently aluminium dust has been added to many other explosives. Other metallic powders, as, for example, magnesium, copper, zinc, iron, silicon, ferro-silicon, certain of the rare metals, and various alloys, are now used for a similar purpose. An example of the composition of a modern high explosive using aluminium dust is as follows: Ammonium nitrate, 45 parts; di- or tri-nitrotoluene, 1905 parts; aluminium dust, 45 parts. The aluminium dust is about 92 per cent pure.

Aluminium dust is frequently adulterated with powders of other metals, particularly zinc and tin, and, at times, also with mica. The difficulty of manufacture accounts for the relatively high cost of the dust, which, in normal times, is almost double that of the metal in other forms. One method of manufacture involves the production of foil by a special system of rolling or combined rolling and hammering. The perfect foil is marketed in that form, while the imperfect foil, usually constituting 65 to 67 per cent of the total, is comminuted in two series of special stamp mills, the finished product being separated by bolting and winnowing. The final operation is the polishing of the dust in a special device. Another method is to force gas and air into molten metal while it is setting, accompanied by vigorous mechanical stirring. The granules thus formed are powdered in special stamp mills or ball mills. The finely ground dust is separated and polished as previously mentioned. In all the methods of making aluminium dust it is necessary to add stearine or some other wax to prevent the welding together of the fine particles during crushing.—*Mining and Scientific Press.*

An Unexpected Water Supply

In excavating for the foundations for a new turbo-generator at the plant of an electric lighting company much water was encountered. To get rid of this a sump was dug, with which a connection was made to the condenser of another large steam motor. In this way not only was the excavation kept clear of water, but the condenser received a supply of much cooler water than from its regular source in an adjoining canal.

Effects of Electrolysis on Underground Piping Systems*

Various Dangers and Methods of Overcoming Them

By Albert F. Ganz, M.E., Professor of Electrical Engineering, Stevens Institute of Technology

UNDERGROUND piping systems for the transmission and distribution of gas, water, oil, and similar materials, consist of lengths of iron pipe joined together with screw couplings, lead or other forms of joint. Screw coupling joints generally have a very low electrical resistance, comparable to the pipe itself. Cast lead or lead wool joints have an electrical resistance which is equivalent to from a few feet to several hundred feet of continuous pipe, so that the resistance of the lead joints in a pipe line is usually much larger than the resistance of the pipe itself. Cement joints generally have a very high resistance, compared with the pipe, so that they may be classed with insulating joints.

Attempts have been made to protect underground pipes from electrolysis by insulating them from earth by paints or dips. Practical experience as well as a large number of tests have, however, shown that no dip or paint will permanently protect a pipe against electrolysis in wet soil. The first difficulty is to apply the paint so as to form an absolutely perfect coating, and the second one is to prevent mechanical damage to the coating during shipment and installation of the pipe. Experience further shows that even where coatings of paints or dips are apparently intact, electrolytic action is not always prevented, and, in fact, very serious electrolytic pittings have been found under apparently good coatings. It has been found that in most cases the applied coatings have either been completely destroyed by the effects of the wet soil and the electric currents, or defects in the coating have developed, causing concentrated corrosion at such defective spots. Where it is attempted to apply a heated material like pitch or asphaltum to a cold pipe, it is impossible to completely cover the pipe. Pitch and similar compounds have been applied to pipes with wrappings of jute or of some similar material. A number of layers can be applied in this way so as to build up any desired thickness of insulating covering. Such covering, if sufficiently thick, will afford protection against electrolysis, provided that it is mechanically perfect. The great difficulty in practice is to install such covering without leaving defective spots through which moisture will have access to the metal of the pipe.

Pipes, where positive to earth, which are covered with imperfect insulating coatings, or coverings exposing bare spots of metal, are in much greater danger from electrolysis than are bare pipes for the reason that the stray currents will leave only from these bare spots, and here produce concentrated corrosion. The writer has seen cases where a pipe coated with an imperfect insulating covering was pitted nearly through in one year, whereas a bare pipe in the same locality was very much less affected, because the corrosion was distributed over a larger surface.

One form of insulating covering which appears to afford certain protection is a layer of one to two inches (2.5 to 5 centimeters) of a material like coal tar pitch, parolite, or asphaltum, of such a grade that it is not brittle, and so will not crack, but yet is hard enough to remain in place. The best way to apply such a layer is to surround the pipe with a wooden box, support the pipe upon creosoted blocks of wood or upon blocks of glass, and then fill the space between the box and the pipe with the molten material. When applying this material great care must be exercised to avoid getting stones or dirt into the mixture, and also to avoid leaving bare spots on the pipe. The cost of carrying out such an installation is prohibitive, however, except in very special cases, such as that of service pipes in very bad localities, or that of very important individual pipe lines of small or medium size. Embedding a pipe in cement or concrete, even if this is several inches in thickness, will not protect it from electrolysis, because damp cement or concrete is an electrolytic conductor.

Current flow of metallic pipe lines can be practically prevented by using a sufficient number of insulating joints. A pipe line laid with every joint an insulating joint has a comparatively high resistance and no substantial current can flow on such a pipe line. It is sometimes possible in the case of individual pipe lines to use comparatively few insulating joints to break up the electrical continuity of the line and substantially protect it from electrolysis, but such joints must be installed only after adequate tests have shown that sufficient current will not leave the pipe on the positive side of a joint to flow to earth and do serious damage by electrolysis. Insulating joints in pipe lines should not be confined to the positive areas, but should be installed in all places along the pipe line where there is any considerable potential gradient in the earth parallel to the pipe. The frequency with which insulating joints must be installed in a pipe line in order to assure reasonable protection from electrolysis depends upon the potential gradient through earth and upon the electrical resistivity of the earth. The effective resistance of a short insulating joint is practically the same as that of a long joint. However, a long insulating joint gives a more even distribution of leakage current than a short joint, and hence a long insulating joint is to be preferred where there is considerable potential difference across the joint, or where the resistance of the surrounding earth is low. The effect of a long joint can be practically secured from a short insulating joint, by surrounding the joint and the pipe for some distance on each side of the joint with a heavy layer of insulating material. In practice, such insulating joints, in important pipe lines, and the pipe for a distance of from 5 to 25 feet (1.5 to 7.6 millimeters) on each side of the joint have frequently been covered with a layer of from one to two inches (2.5 to 5 centimeters) of insulating compound.

Where small service pipes are endangered by current which flows to them either from the main or from house piping, such current flow can be prevented and the service pipe protected by placing an insulating joint in the service pipe at the main or in the building.

Transmission pipe lines, made up of iron pipes with electrically conducting joints, frequently extend across country for many miles, and such pipes may cross and parallel electric railway lines of the same or of different systems. The writer has investigated a number of pipe lines of this kind and has frequently found that stray currents from the electric railways reaching these pipes have seriously damaged them by electrolysis. It is often found that the stray currents will flow to and from the pipes not only where these are close to electric railway tracks, but also in localities many miles away from such tracks, and in sections of country, like open fields, where there are no other underground metallic structures. Attempts have been made in some of these cases to protect the pipe line by installing insulating joints at a few points in the line, especially at crossings of electric railway tracks. It has generally been found, however, that the pipe on one side of the joint was thereby rendered highly positive in potential to the surrounding earth, resulting in rapid destruction of the pipe on the positive side of the joint, thus causing more acute danger than existed before, when the current left the pipe over a more distributed area. In some cases where large currents were found flowing between long-distance pipe lines and the tracks of electric railways at points of crossing, considerable improvement was produced by employing broken stone ballast and keeping the tracks out of contact with the ground for several hundred feet on each side of the crossing, thereby greatly increasing the resistance from tracks to earth. In general, however, satisfactory protection of long-distance pipe lines, under conditions where stray currents from electric railways flow to and from them over extended areas, cannot be obtained by any remedial measures which can be applied to the pipes.

It is occasionally found in long pipe lines that large currents flow to and from localized sections of the line where there are many electric railway tracks and where the pipe is relatively close to these tracks. In some cases, the pipe in such localized sections has been protected by insulating joints spaced with sufficient frequency to prevent dangerous voltages across any one of the joints. In other cases, the pipe in such a section has been covered with a thick layer of insulating material, and, as an additional precaution, insulating joints have been installed in the pipe at each end of the insulating covering, so that if any defective spots in the covering should develop, no current can reach the pipe at these spots and produce electrolysis. In an investigation extending over about 100 miles (161 kilometers) of an 8-inch (20.3-centimeter) steel cross-country pipe line, made by the writer, stray currents from neighboring electric railways were found at all points tested. In a section of about 6 miles (9.7 kilometers) of this pipe line, where it crosses and runs close to a number of electric railway tracks, large stray railway currents were found flowing to and from the pipe and causing serious corrosion of the pipe by electrolysis. In order to protect the pipe in this region against this very acute danger, twenty-six insulating joints were installed at selected points, and portions aggregating a total length of about 3½ miles (5.63 kilometers) of pipe were also covered with one to two inches (2.5 to 5 centimeters) of parolite surrounded by a wooden box, with the pipe resting on rectangular glass blocks. At both sides of this insulated section it was found that neither insulating joints nor insulating covering could be safely applied to protect the pipe without carrying the insulation practically over the entire length of the pipe, which would have been prohibitive in expense. Protection of the pipe here can be secured only by adequate improvements in the electric railway systems.

Where considerable currents leave a relatively short section of pipe and endanger it by electrolysis, this section can be protected by surrounding it with an auxiliary pipe electrically connected to it, so that the current will leave from the auxiliary pipe. This is called "shielding."

It is sometimes found that underground pipes and other metallic structures of a gas works receive stray currents from the various pipes which connect the works to outside piping systems. Since stray currents are particularly objectionable here, on account of electrolysis and also possible danger from electric sparks, the entrance of such currents has, in some gas works, been prevented by installing insulating joints in each of the pipes connecting to the works.

In one gas works, which is located on a salt water inlet opposite the railway power station, large stray currents were found flowing through the gas works and endangering not only the piping of the works, but also the bottoms of tanks. At the railway power station the negative bus-bar was connected by bare underground cables to tracks directly in front of the station; and this caused stray currents to concentrate toward this power station, some of which, in their path, flowed through the gas works. In the case of two oil tanks stray currents of considerable magnitude were found to flow to the tanks from the connecting oil pipes and thence to earth; to protect the tanks, insulating joints were installed in these pipes, thereby preventing the entrance of current. The stray currents through the works were later sufficiently eliminated by disconnecting the bus-bar at the power station from the tracks and from all ground contacts, and installing insulated return feeders to points in the tracks surrounding the gas works, which feeders were proportioned for equal voltage drops. In this way a substantially equipotential zone was set up around the works, and the former tendency for current to flow through the works was removed.

While in a number of American cities electrical drainage has been applied to both the gas and water piping systems as a protection against electrolysis, no complete tests of an extensive electrical drainage system applied to pipes are available, so far as the writer is aware. Such tests as have been published consist only of current measurements on the pipes and of potential measurements between the drained pipes and trolley tracks. The complete data from which to judge the effectiveness of the system would involve the results of many other tests, particularly of measurements of drop across joints in the pipes, and of measurements of potential difference between the drained pipes and other underground structures.

Electrical drainage was first applied to lead cable sheaths, and the success in protecting cable sheaths in this manner led to the attempts to apply the drainage method also to pipes. There are marked differences, however, between an underground piping system and a lead cable system, which render the piping system much less suited for electrical drainage. The principal difference is that cable sheaths are continuous electrical conductors, while pipes may be more or less discontinuous, due to the presence of high resistance joints. Another difference is that the lead cable sheaths are relatively small and are carried in ducts, which are mostly non-metallic, so that only part of the surface of the cables is in contact with earth, whereas underground pipes are buried directly in earth and generally present enormous contact areas to earth. The result is that when electrical drainage is applied to pipes, the currents on the pipes are very greatly increased. This results in danger of current shunting around high resistance joints or leaving the pipe on the positive side of a joint to flow to other structures. One case of this kind is reported to the writer where a 4-inch (10-centimeter)

* An address before the International Engineering Congress at San Francisco.

cast-iron water main, which was electrically drained to the street railway tracks, was badly pitted, causing a water leak on one side of a sleeve coupling. The pipe for some distance on this side of the sleeve was also badly pitted. In this case the sleeve had undoubtedly developed high resistance and current was leaving the pipe on the positive side of the sleeve.

If the pipe which is electrically drained is one which conveys an inflammable liquid or gas, or if it passes through a manhole or other confined space where inflammable gases may collect, the flow of stray current on the pipe may involve the danger of an explosion or fire, particularly at times when the continuity of the pipe is interrupted for repairs or for other causes. Many cases have been reported where in interrupting or rejoining or recalking mains, electric arcing was produced. The writer has found that in a number of cities where pipe drainage is employed it is the general practice, when mains are to be interrupted or a joint is to be recalked, to first connect a heavy copper wire across the proposed break, so as to prevent danger from arcing. The writer has also found one case where a high-pressure gas main pulled apart at a joint in an open ditch, and the arc caused by the interruption of the main ignited the gas and made it necessary to shut off the gas from this main, and thereby the gas supply for an entire town, in order to extinguish the flames and repair the break. In this case the gas main was electrically drained to the power station and carried a large current.

In the October, 1914, *Quarterly* of the National Fire Protection Association two cases of gas explosions are described which were caused by gas leakage from pipes which had been pitted by electrolysis, which pipes were electrically drained.

Where both gas and water service pipes enter buildings, the result of producing large stray currents on the pipes is, generally, also to produce a flow of these stray currents through buildings, the current flowing in on one service pipe, passing to the other service pipe through metallic contacts in the building, and then flowing out on the other service pipe. Such stray currents through buildings constitute a serious fire hazard. In the National Fire Protection Association *Quarterly* referred to above, a case of this kind is also described, where a gas service pipe showing marked pits from electric arcing with a water service pipe was taken from the cellar of a building. The writer has also seen cases where severe arcing was produced between water and gas service pipes in buildings whenever there was a vibration of the pipes.

The complete application of electrical drainage to pipes will involve draining all underground piping systems, and, in fact, bonding together all underground metallic structures affected by the stray currents, in such a way that at every point where different structures come into proximity in earth, they are brought to practically the same potential. If this is not done there will be at such points a flow of current through the earth from the structure of higher potential to that of lower potential, thus causing corrosion of the former.

When electrical drainage is applied to a single system of underground pipes, without making a complete investigation of the effects of possible high resistance joints, etc., the installation may be made at relatively small cost, and when so applied, it usually relieves the acute danger from electrolysis in the immediate neighborhood where the drainage connections are made. Both of these considerations have served to favor the electrical drainage system. However, a single drained underground piping system becomes a source of serious danger to other systems. If electrical drainage is applied comprehensively to all underground metallic systems, it will not only be found very expensive to install, but likewise expensive to maintain, because as railway and piping systems are changed the drainage system must be changed accordingly. The large increase in current on underground structures produced by electrically draining them also brings about dangerous conditions at scattered and unknown places, which is a serious objection to this method. As an example, in Pittsburgh, where electrical drainage is extensively applied to the water and gas pipes, it is reported (*Proc.* The Engineers' Society of Western Pennsylvania, July, 1911) that drainage cables aggregating 17,000,000 circular mils (86 square centimeters) in cross-section connect to these pipes from the main railway supply station, and that the current drained from these pipes is nearly one half of the total station current.

In the future installations of underground piping systems in the neighborhood of electric railways, precautions should be taken to minimize flow of stray current to the pipes. To this end the pipes should be laid as far from the electric railway tracks as practicable. Metallic contacts with the tracks, such as may exist at iron gate or similar boxes used in water piping systems, must be carefully avoided. Where the pipes cross steel bridges carrying electric railway tracks in metallic contact with the bridge structure, the pipes should be supported on wooden blocks or otherwise insulated from the metal of the bridge structure. Insulating joints should be installed at the entrance of pipes to car barns, as it is frequently found that the pipes inside of the barns are in metallic contact with the tracks through the building structure. In special cases of individual pipe lines insulating joints, and in some cases also insulating covering of adequate thickness, may be employed in localized sections where conditions are found to be suited to their installation.

The Food Supply of the German People

The problem of the food supply in Germany has been the subject of much discussion, so a survey of the conditions during the first ten months of the war, as set forth in a pamphlet[1] recently published in Germany, will be of general interest.

We are indebted to *The Lancet* for the following summary of a portion of the publication in question:

"In time of peace our imports in foodstuffs had exceeded our exports by about one tenth of the whole, and the same proportion held good in respect of fodder. On the outbreak of war imports ceased, and though the export of foodstuffs was at once forbidden, the result of this measure was not so favorable as it might have been owing to the difficulties, brought about by the war, in the bringing in of the harvest. By means of careful measures, such as forbidding the use of foodstuffs suitable for human consumption as fodder, any great hardship was avoided, but the supply of fodder, which *in toto* contains about double the amount of nourishment present in foodstuffs for human consumption, was reduced owing to the cessation of imports and a meager harvest by about one fifth. A part of the deficiency of food and fodder could be supplied by greater thrift. To make up the remaining shortage a judicious reduction in the number of head of cattle was ordered, due care being taken that the number of horses, stock cattle, and milch cows should be reduced as little as possible. Unfortunately these measures were not carried out so thoroughly and energetically as they should have been, and the sufficient feeding of the population and of the indispensable cattle became jeopardized and even for the time impossible.

CATTLE.

"The year 1913 was marked by a record harvest of grain and other kinds of fodder, and at the outbreak of war the condition of the cattle was unusually favorable. In 1914 the harvest was not so good, and had peace continued the condition of the cattle would probably have been correspondingly less satisfactory; but the outbreak of war caused an agricultural crisis and the decline in the condition of the cattle was thus enhanced. Unfortunately it was only here and there that the crisis was adequately dealt with, and in some places the slaughter of calves under 75 kilogrammes in weight, and of cows under the age of 7 years (even in the case of bad milkers) was forbidden by law, and the slaughter of pigs discouraged; with the result that on December 1st the number of pigs was greater by 33,926 than on June 2nd, and the number of cattle had also increased. In December and January there was as usual a decline in the number of pigs, and this was greater than the average, owing to increased slaughtering and the less prolific breeding caused by the agricultural crisis. Meanwhile the Government had determined that more pigs must be slaughtered, and on January 25th recommended all communes of more than 5,000 inhabitants to buy up a great number of pigs. The price of pigs, however, rose to double that of peace time, and the recommendation of the Government was only halfheartedly carried out. On April 15th a new census of pigs was taken, showing a drop since December 1st of 35 per cent, and it seemed to the Government that the reduction had proceeded far enough. In the latter half of April and during May, however, the numbers began to rise again, and by the end of May were probably as high as they had been in the middle of March. If the reduced number of pigs of the middle of April had been attained six months earlier and had remained fixed it would have made a vast difference in supplying the needs both of the population and of the indispensable cattle. As it was, great quantities of grain and potatoes were given to pigs and no very considerable gain in meat attained, while the other cattle suffered, and particularly the horses, which already in February were on reduced rations of oats, though the harvest of 1914 would have been sufficient for their needs in spite of the unusually great demands of the war horses; and through this reckless usage the store of oats had by December 1st been reduced by one half. Several measures were then passed limiting the consumption of oats and confiscating all stores. Thus delay and wastefulness in the first six months of the war was followed by a shortage in the supplies of oats for the cavalry horses, and such reduced rations for the horses at home, particularly those employed in important agricultural work, as would materially injure their working capacity.

CEREALS AND POTATOES.

"After the harvest of 1914 our supplies of wheat and rye were so copious that in spite of the cessation of imports we could have consumed as much bread as in time of peace. On October 28th, 1914, and January 5th, 1915, the Bundesrat passed measures making it obligatory for first 72 per cent, and later 82 per cent. of rye and from 75 per cent. to 80 per cent of wheat to be ground into flour. At the earlier date, in consideration of the fact that the harvest of 1914 had not been so good as that of the year before, the use of cereals as fodder ought to have been limited to ensure a sufficiency until the next harvest. But it was not till November 4th that the unlimited use of cereals for feeding cattle was forbidden. This was not sufficient to put a stop to the mischief, and on December 1st, after four months of war, it was found that the stores from the last harvest had been reduced by about one half. If this rate of consumption had continued, Germany would have found herself by April entirely without wheat and rye. On the other hand, if on December 1st the grain stores had been controlled by the Government it would have been possible to assure to the population 300 grammes of flour per head daily. But the Government contented itself with forbidding the use of cereals as fodder, and publishing official notices that whoever disregarded this prohibition would be guilty of a sin against the Fatherland, all of which was in vain, and in December and January greater quantities of rye and wheat were given to cattle than in peace time when no prohibition existed. It was not until January 25th, 1915, that the Government took the supplies of wheat and rye into its own hands and declared that those engaged in agriculture should have an allowance of 72 kilogrammes of flour per month per head, and the rest of the population 225 grammes daily per head. Even these retrenchments were insufficient. In February only one third of the grain store remained, and the allowance of 225 grammes was reduced to 200. (In time of peace the average consumption per head is 340 grammes, so that the people had now to deny themselves 14 per cent of their accustomed nourishment, and for the poor, with whom bread is a more important item, it was 25 per cent, or even higher."

"The great error, then, in the management of the cereal supply was that the right solution had been found too late. When once the need was thoroughly realized the measures taken were excellent. That the flour rations at this time were not more generous was in the nature of a wise precaution; that the price of flour nevertheless remained so high may be attributed to the tardiness with which the Government had taken over the supplies of corn.

"Germany produces more potatoes than any other country in the world, but the crop of 1914 was below the average, and it was clear that in spite of curtailment of industrial consumption (alcohol, starch, etc.) 22 million tons must not be used for fodder as they had been in time of peace, for potatoes had to take the place of other foodstuffs that were lacking. For this purpose it was calculated that 20 million tons ought to be kept in reserve. To attain this end the 22 million tons which had formerly been used as fodder must be reduced to 12 million tons. Instead of this being done, during the first months of the war the use of potatoes as fodder actually increased, and was even mistakenly encouraged by the Government—e. g., on October 15th, when a recommendation was issued that in view of the unusually large potato crop and the deficiency in fodder, potatoes in every form should be used to replace imported fodder. A very low maximum price was fixed for potatoes, which encouraged waste and, as in the case of cereals, a serious depletion of the stores obliged the Government to change its policy. On January 9th the Prussian Minister for Agriculture declared that owing to the increased use of potatoes for human consumption consequent on the lack of cereals and imported foodstuffs, the recommendation to a freer use of potatoes for fodder had not produced the desirable effects that had been anticipated. On February 15th, in order to hinder the feeding of cattle on potatoes, the price of the latter was raised from M. 35 a ton to M. 85-96 a ton, and a few days later the Kaiser declared that the use of potatoes as fodder was forbidden. But the supplies had already been seriously depleted. People who in time of peace consumed on an average 550 grammes of potatoes daily now took considerably more both as vegetable and also mixed with flour in the bread, while owing to the lack of barley and maize pigs had been fed very largely on potatoes, and a great deal

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[1] Unsere bisherige und unsere künftige Ernährung im Kriege. Von R. Kuczynski, Direktor des Statist. Amtes der Stadt Berlin-Schöneberg, und N. Zuntz, Direktor des Tierphysiolog. Instituts des K. Landwirtsch. Hochschule, Berlin. (Friedr. Vieweg und Sohn, Braunschweig, 1915.)

more than usual had been consumed by cattle and horses. Thoughtful people were urgently recommending the taking over of the potato supplies by the Government as had already been done with the cereals, and the Reichstag took the matter under consideration, first ascertaining what supplies remained in the country. The results of this inquiry were, however, not conclusive. The Government now realized the necessity of securing a supply of potatoes for the population of the towns, though it was not yet prepared to take over the whole potato supply, a measure which it declared impracticable owing to certain technical difficulties. It decided, however, to secure 2 million tons for the use of the poorer classes in towns, and appointed a 'Reichsstelle für Kartoffelbe-orgung' to deal with the matter. In buying, the maximum price holding good in any particular district would be paid, and in addition a sum—beginning at M. 20 and rising to M. 80—to cover storage, loss by rotting, etc. It was hoped that this additional tax would be an inducement to the farmers to sell and would hinder the use of potatoes as fodder. Unfortunately the farmers were not so willing to sell as was expected, and the Government was only able to obtain about a tenth part of the quantity it had resolved to buy. It was on April 12th that the 'Reichsstelle' came into force. It decided which supplies were to be given up directly to itself or to the communes, but where possible the supplies were to be acquired by a voluntary sale on the part of the farmers. The conditions of buying remained as before. Where supplies of potatoes within a district were insufficient for the needs of the population in that district the commune was to send an initial notice on May 20th, though in cases where the farmers refused to sell the communes were empowered to appropriate the supply. Even these measures failed to elicit the required quantity, and now the inevitable results of this dilatory and half-hearted legislation began to make themselves felt. Innumerable people had on the rising of prices suddenly taken to the potato business, and being unable to store the potatoes suitably, found themselves obliged to sell at a very low price. For example, prices sank by a third and more within a month in Berlin, just at the time of year when a rise was usual. The communes thus made much smaller final demands on the stores so dearly acquired by the 'Reichsstelle' than their provisional demands of May 1st, while at the same time the military commissariat administration required only 17,600 tons instead of an estimated 200,000 tons, and the 'Reichsstelle' was left with a surplus. The ultimate result of the delay in securing supplies for the poorer classes was an ever-increasing potato famine and corresponding rise in prices. In this matter, again, had the Government in good time taken the control of the whole potato supply into its own hands these evil consequences would have been avoided.

STANDARD OF LIVING.

"For the first six months of the war the condition of the food supply was not less favorable than in time of peace. Unemployment had indeed increased greatly, but the percentage of unemployed connected with the trades unions sank little by little from 22.4 at the end of August to 6.5 at the end of January, the latter being about double that in time of peace. At the same time food prices had risen steadily in spite of all efforts to prevent this, although in many trades wages had risen correspondingly. Later on, however, as the cereal supply began to run short and a bread ration was fixed, the poorer classes lost about 20 per cent to 25 per cent of their staple diet. The price of rye bread in January, 1915, had risen 33 per cent, and in May 53 per cent, wheat bread 26 per cent to 35 per cent, as compared with prices in January, 1914, and May, 1914. With other foods prices had risen on an average by 81 per cent from May, 1914, to May, 1915. This is, however, misleading, in that certain foods—e. g., lentils, semolina, etc.—which had risen greatly in price since the outbreak of war, had been consumed in much greater quantities than in time of peace, so that, taking this into account, an average rise in prices of 52 per cent may be estimated. This great rise in prices forced the mass of the people to buy the cheaper kinds of food and also to buy smaller quantities. A great deal of the difference was accounted for by more careful cooking and usage—e. g., cooking potatoes in their skins and so forth; but in such foods as meat, milk, etc., such a saving was not possible. Conditions were thus very grave for the working classes, more especially as potatoes and pulse, which might largely have taken the place of meat and bread, had become scarce and therefore expensive. Briefly, the situation from February or March onward was one of enforced moderation with health-giving results to hundreds of thousands of overfed people, but implying for the masses a weakening of their working capacity by hardship which amounted to actual want. A few months of such conditions might do no great harm, but their long continuance would threaten the country with grave danger."

A Mechanism of Protection Against Bacterial Infection*

By Carroll G. Bull

THE means employed by the animal body to rid itself of bacteria have been conceived to be of two kinds: those of disintegration or lysis, and those of cellular inclusion or phagocytosis.

According to the former, the bacteria are acted upon by certain constituents of the blood serum—amboceptor and complement—which dissolve them; and according to the latter they are englobed by white blood corpuscles which digest them.

As a matter of fact, the first process has been inferred, rather than demonstrated. It is true that in shed blood the dissolution by lysis has been observed, but not in the living body. But even in shed blood or its serum constituents the solution occurs only with a part of the pathogenic bacteria, of which B. typhosus may be taken as an example. Such bacteria as pneumococcus, streptococcus, etc., are not subject directly to this form of dissolution. Phagocytosis, on the other hand, is a more general phenomenon and applies to a wide variety of bacteria.

It has long been known that when bacteria are introduced into and later disappear from the blood, they are not eliminated by the organs of excretion, but are destroyed in the organs themselves. The problem at issue relates to the manner of the destruction.

The question should be considered with reference to two states of the animal body, namely, the unprotected or normal, and the protected or immune state.

Taking certain forms of pathogenic or disease-producing bacteria, a study was made as to the manner of their disappearance in protected rabbits. The pneumococcus and typhoid bacillus may serve as examples. Protection was secured by the employment of immune sera. In the case of the pneumococci, the type of pneumococcus and immune serum must coincide. In the experiments a type I pneumococcus and corresponding serum were employed.

Protection Against Pneumococcus.—It has been shown that an active pneumococcus serum protects against a certain maximum quantity of pneumococcus culture, but that multiples of the serum do not protect equally against multiples of the culture. An effective culture of pneumococcus causes on inoculation fatal septicemia in the rabbit, followed by death in twenty-four to forty-eight hours or less. When an immune serum is employed, life may be saved or the surviving period merely prolonged.

The immediate effect of a serum injection is to cause the removal of the pneumococci from the circulating blood. This effect is produced in an incredibly short period of time—in a few minutes indeed. But the permanency of the removal depends in part on the quantity (or dose) of antiserum injected. Small doses of serum are more effective than large doses, and the former may be successful in saving life, while the latter are not.

The mechanism of the removal is as follows: when an immune serum is introduced into the blood of a rabbit suffering from pneumococcus septicemia, an almost immediate agglutination of the bacteria takes place. The larger the doses of the serum, within limits, the larger the size of the bacterial clumps that are found. The clumps are removed from the blood almost immediately by the organs—the spleen, liver, and bone marrow. What happens next is determined by the size of the clumps. If they are large, they cannot be ingested by phagocytes; hence they soon begin to multiply, and the bacteria reinvade the blood; if small, they are taken up by phagocytes and are digested. The animal succumbs on the one and survives on the other hand. Hence small doses of the serum causing smaller clumps may be more effective than large doses giving larger ones. No extra-phagocytic dissolution of the pneumococci seems to occur.

Protection Against the Typhoid Bacillus.—A similar mechanism operates in the rabbit inoculated with cultures of the typhoid bacillus. The typhoid bacilli, notwithstanding the fact that they are subject to serumlysis, are taken out of the blood by the organs after clumping, and the clumps are ingested by phagocytes which digest them.

Pathogenic and Non-Pathogenic Bacteria.—Certain cultures of disease-producing bacteria are not, others are pathogenic for animals. The influenza bacillus appears in these two distinct varieties. When cultures by the non-pathogenic variety are injected into the circulation of rabbits, they are clumped and removed by the organs at once; when cultures of the pathogenic variety are inoculated, they are neither clumped nor removed. Hence a pathogenic effect may depend upon agglutinability of the bacteria—by the blood of normal or of immunized animals.

In other words, bacteria circulating in the blood are quickly removed when they are agglutinated or clumped, and the clumps deposited within the organs are taken up by phagocytes and digested. They appear not to be destroyed by solution or lysis through the operation of serum constituents of the blood.

* Presented to the National Academy of Science, and republished from the *Proceedings*.

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